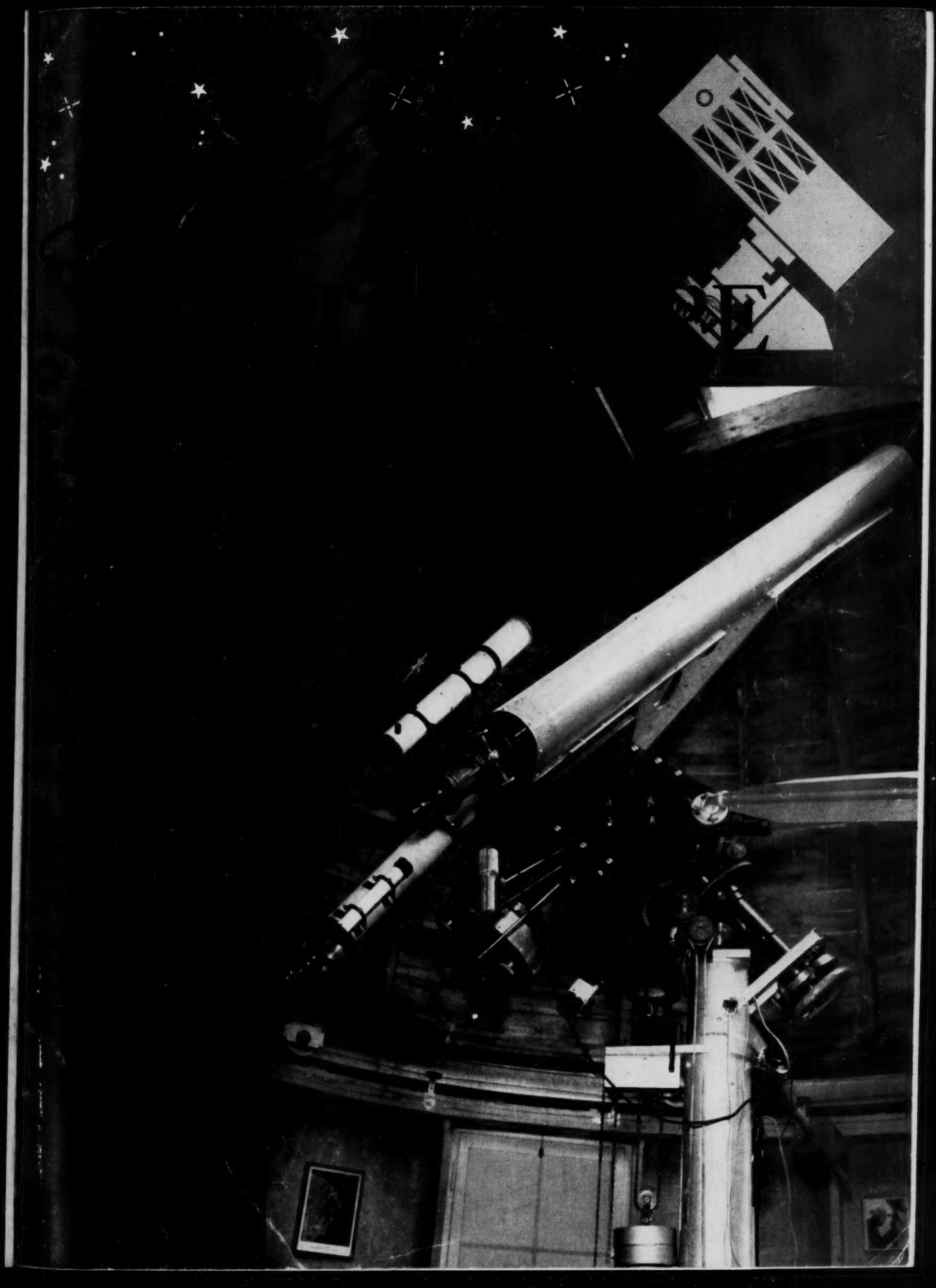

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Sky and TELESCOPE

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Vol. XVIII, No. 2 DECEMBER, 1958

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# Variable Stars Today

A LARGE and important part of present-day observational astronomy is the study of stars that change in brightness. Every kind of instrument is used, ranging in size from the 200-inch reflector for observing variables in other galaxies to the unaided eye of the amateur who estimates the brightness of Mira.

To mention only a few aspects of this world-wide effort, in Oklahoma and Poland observers are systematically timing the minima of eclipsing binaries; German, Dutch, and Soviet astronomers are making wholesale surveys of the sky with fast, wide-field cameras; and photoelectric measurements of variables are being carried out at a score of American observatories.

The information center for this network of observers is at the Sternberg Astronomical Institute in Moscow, where the observational results are collected and catalogued. From there are distributed lists of newly discovered variables, as well as the only journal in the world solely devoted to variable stars.

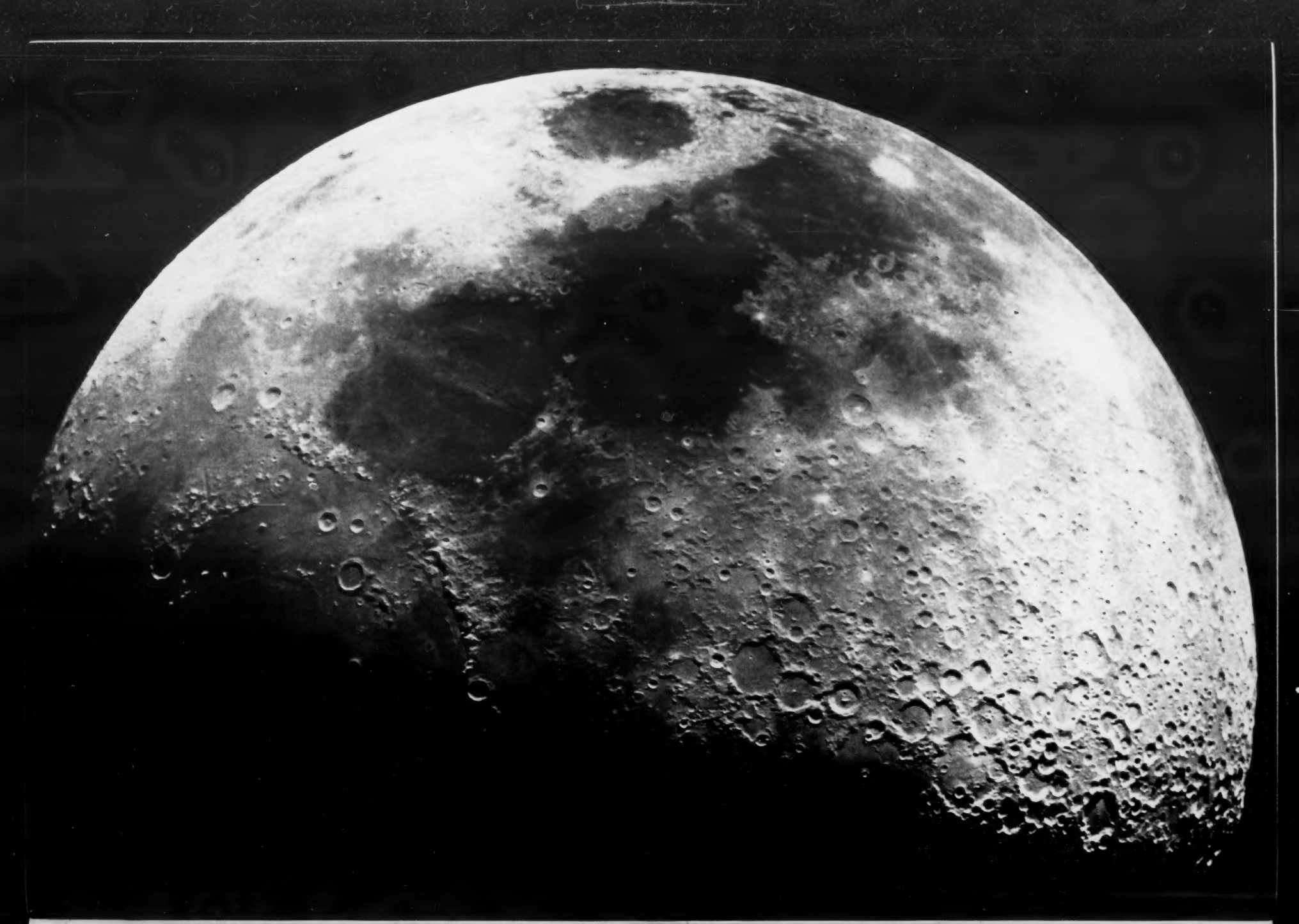
A most valuable reference work was published by the Sternberg Institute this year, the new two-volume *General Catalogue of Variable Stars,* which supplants the one-volume catalogue issued in 1948. It is the joint work of B. V. Kukarkin, P. P. Parenago, J. E. Efremov, and P. N. Kholopov. Here are collected in concise form all the basic data for the 14,708 stars officially named as variable up to the year 1958. The catalogue does not include variable stars in globular clusters nor in the Magellanic Clouds or other extragalactic systems.

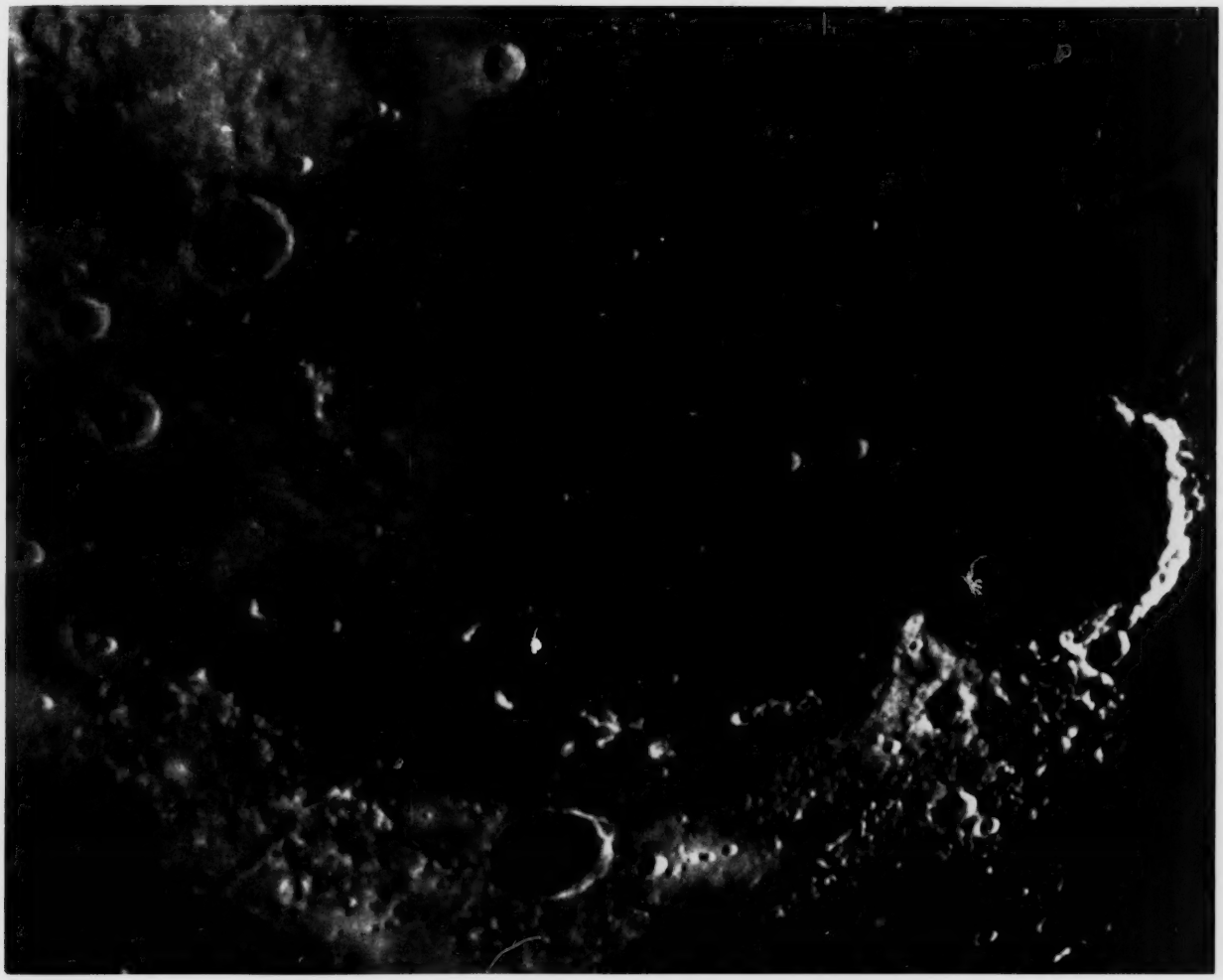
The first volume lists the stars by constellation, giving for each its position, magnitude limits, type of variation, spectral class, and elements for predicting times of maxima and minima. References to charts and bibliographies for individual stars are a welcome feature.

In the second volume are tables to facilitate the identification of variables. For example, a star may have half a dozen aliases under which it is described in the literature, such as its BD and Henry Draper numbers, provisional number, and Harvard Variable number. The tables of synonyms reduce this chaos to order.

More important, perhaps, are the lists of variables belonging to each type. There is a careful sorting of stars into about 40 categories. This is the first catalogue, for example, in which the Population II Cepheids are distinguished from those of Population I. The list of long-period variables has 3,657 stars, while there are 2,763 eclipsing systems catalogued.

The amount of information in the new Moscow *General Catalogue of Variable Stars* is so great that it cannot fail to be a powerful stimulus to further advances.





**A portion of the great lunar plain Mare Imbrium, from a Kutter photograph. At the extreme right, the Jura Mountains are brilliantly lit by the rising sun, on the border of semicircular Sinus Iridum (Bay of Rainbows). Dark-floored Plato, at bottom center, is 63 miles across, and the 50-mile ring Archimedes is toward the upper left. See page 92 of this issue for a photograph of part of this region, taken with the 100-inch Mount Wilson reflector.**

# Moon Photographs with an Off-Axis Reflector

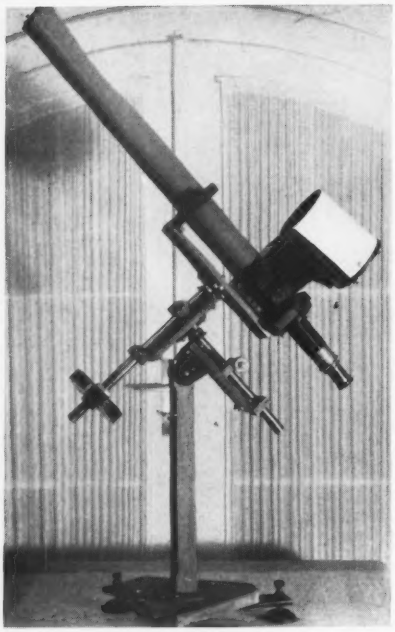
**FACING PICTURE: The moon about one day past first quarter (age 8¾ days), enlarged from a negative taken by Anton Kutter with his 12-inch oblique reflector on January 28, 1958, at 16:23 Universal time. The exposure was one-third second on a Hauff-Pancrosin plate, developed seven minutes in Rodinal, diluted one to 35. Compare the bottom-center portion with the larger-scale view at the top of this page, which was taken nearly two days later in the lunar month. The large walled plain Plato is conspicuous in both cases. On page 67 is another photograph in which the upper part of the first-quarter moon is shown on an enlarged scale. All moon pictures with this article are by Mr. Kutter, using the telescope pictured on the front cover, stopped down to a mirror aperture of 10 inches.**

MORE amateur astronomers should look through the eyepiece of a modern off-axis reflecting telescope and experience the beautifully defined lunar and planetary images it provides. This optical design gives sharper definition by eliminating the diagonal and supporting struts inside the tube, which cause unwanted diffraction effects.

In recent years the off-axis reflector has been developed to a high state of perfection by the telescope maker and amateur astronomer Anton Kutter, of Biberach an der Riss, Germany. His interest in this problem was stimulated a quarter-century ago by his friend and astronomical mentor, Philip Fauth (1867-1941). This famous German observer of the moon and Jupiter used a telescope of a related type, a 15-inch Schupmann-medial. A portrait of Fauth hangs on the interior wall of Mr. Kutter's private observatory, pictured on the front cover. The telescope there is the 12-inch off-axis reflector made by Mr. Kutter with which he took the lunar photographs accompanying this article.

The picture of Mare Imbrium above is reproduced on a scale that would make the lunar disk about 25 inches across. Even though some of the detail in the original negative has been lost in the engraving, the latter shows distinctly craterlets only two miles in diameter, with their interior shadows.

This scene, like the others, has south at the top, corresponding to the view in an inverting telescope. According to astronomical usage, lunar west is toward the left, and east toward the right. At the time the Imbrium photograph was taken, March 30, 1958, at 18:39 UT, the



**This 4.3-inch oblique anastigmatic-type reflector by Mr. Kutter is similar to the one used for the moon pictures, but it does not have a cylindrical correcting lens. Incoming light falls on a spherical primary mirror, in the short white tube, and is returned upward through an opening in the longer tube. There a convex spherical secondary mirror forms the final image at the lower end of the main tube, as in a refractor. The secondary obstructs the primary slightly, covering only three per cent of its area; coma is reduced to an undetectable amount. This f/20 reflector gives fine definition for visual observations of the moon and planets and is recommended by Mr. Kutter for instrument makers of intermediate experience.**

sun was rising on the floor of Sinus Iridum, which is 152 miles across. The Jura mountain range that forms its rim has peaks rising to 13,000 feet, according to measurements by J. F. J. Schmidt.

A conspicuous feature is the scattered line of isolated mountains, beginning near the western end of Sinus Iridum, that runs in a long curve across the smooth expanse of Mare Imbrium. It can be traced to Spitzbergen, the compact bright triangle of hills lying northeast of Archimedes in the upper left. When this same region is inspected in the photograph on page 64, it is seen that a series of low ridges also marks the course of the arc of mountains.

Turning now to the photograph on the facing page, a wide variety of formations worthy of detailed observation is presented. The famous Straight Wall is well shown, a long thousand-foot cliff casting a striking shadow on the lower land to the east. Its southern end touches the 2,300-foot Stag's-horn Mountains. The ridges to the southeast help give the impression of an immense ruined crater some 120 miles across, with the Straight Wall lying on a diameter.

A little farther south is another huge plain, which for a brief interval each month also presents the appearance of a badly damaged crater. Usually it is known as the Hell Plain, from the largest crater inside this enclosure (named after a Jesuit astronomer of the 18th century). Near the western side of the Hell Plain is a tiny white mark which becomes very conspicuous near full moon. This is the Cassini bright spot, first described about 270 years ago.

Nearer the top of the picture, the great crater Maginus has a distinctly lozenge-shaped outline. Despite its conspicuousness in this photograph, at the time of full moon this formation becomes unrecognizable in the general glare of its surroundings.

Look above Albategnius and to the left of Alphonsus for a curious pattern of delicate furrows, all running approximately parallel to the Straight Wall. Such patterns — for there are similar arrays on other parts of the moon — are currently being widely studied by lunar observers.

On the floor of Alphonsus, a distinct dark spot can be seen just inside the eastern rampart, and another is southwest of the central peak. A third such spot is hidden by the west wall's shadow. They appear startlingly dark at full moon. Nevertheless, they probably do not actually darken under a high sun, as W. H. Pickering thought; instead, they are likely to be patches that do not brighten as much as their surroundings.

Excellent as these photographs are, they do not represent the full capabilities of a 12-inch telescope of this type. Last winter, when the moon pictures were made, the primary mirror had not received its final figuring, still having a turned-down edge and zonal defects. Therefore, the aperture was diaphragmed down to 10 inches. In addition, the experimental photographs were made under comparatively unfavorable seeing conditions, as Mr. Kutter's housetop observatory is located inside a town of 20,000 inhabitants.

The instrument is similar to the neo-brachyt described on page 529 of the August issue, but uses a weak spherical corrector lens placed between the final focus and the secondary mirror. This lens is rotatable about its horizontal axis and movable along the optical axis, and can be adjusted to reduce coma and astigmatism to negligible amounts.

Mr. Kutter points out that the fundamental system of his "Schiefspiegler" is the Cassegrainian, but not in the classical short-focus form with high amplification by the secondary. Instead, the primary is of long focus (f/12) and the secondary amplifies less than two times. This combination of optics preserves the long-focus features of the primary; both it and the secondary can have spherical figures unless the telescope's aperture is more than nine inches. In that case, the primary is made elliptical, and the secondary remains spherical.

In this system, the primary and secondary have approximately equal radii of curvature, so the Petzval condition is practically satisfied and the field of view is flat, not curved. If the amplification is increased to get even higher magnification for lunar and planetary work, the flat field of view becomes restricted to about half a degree for amplifications of two or 2½ times. When this is done in an ordinary Cassegrainian, the increased image size is achieved at the expense of enlarging the secondary.

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EDITOR'S NOTE: For readers wishing more details of Anton Kutter's telescope designs, we have prepared SKY AND TELESCOPE *Bulletin A*. This is an unedited reproduction of a 21-page manuscript by Mr. Kutter, written in English, giving technical design data on oblique and catadioptric telescopes. The typewritten original has been photo-offset to half its original scale, and two photographs and several diagrams are included. *Bulletin A* may be obtained by sending 25 cents, to cover mailing costs, to Sky Publishing Corporation, Harvard Observatory, Cambridge 38, Mass.

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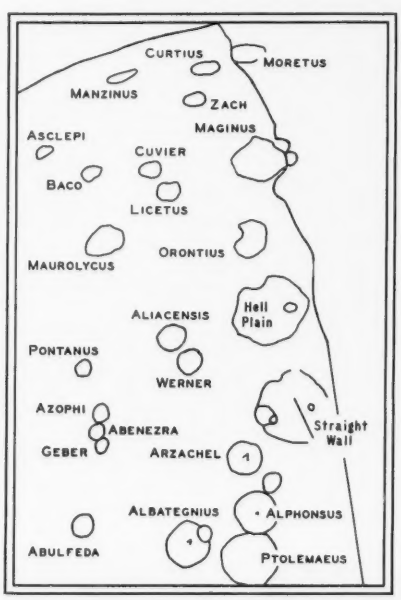
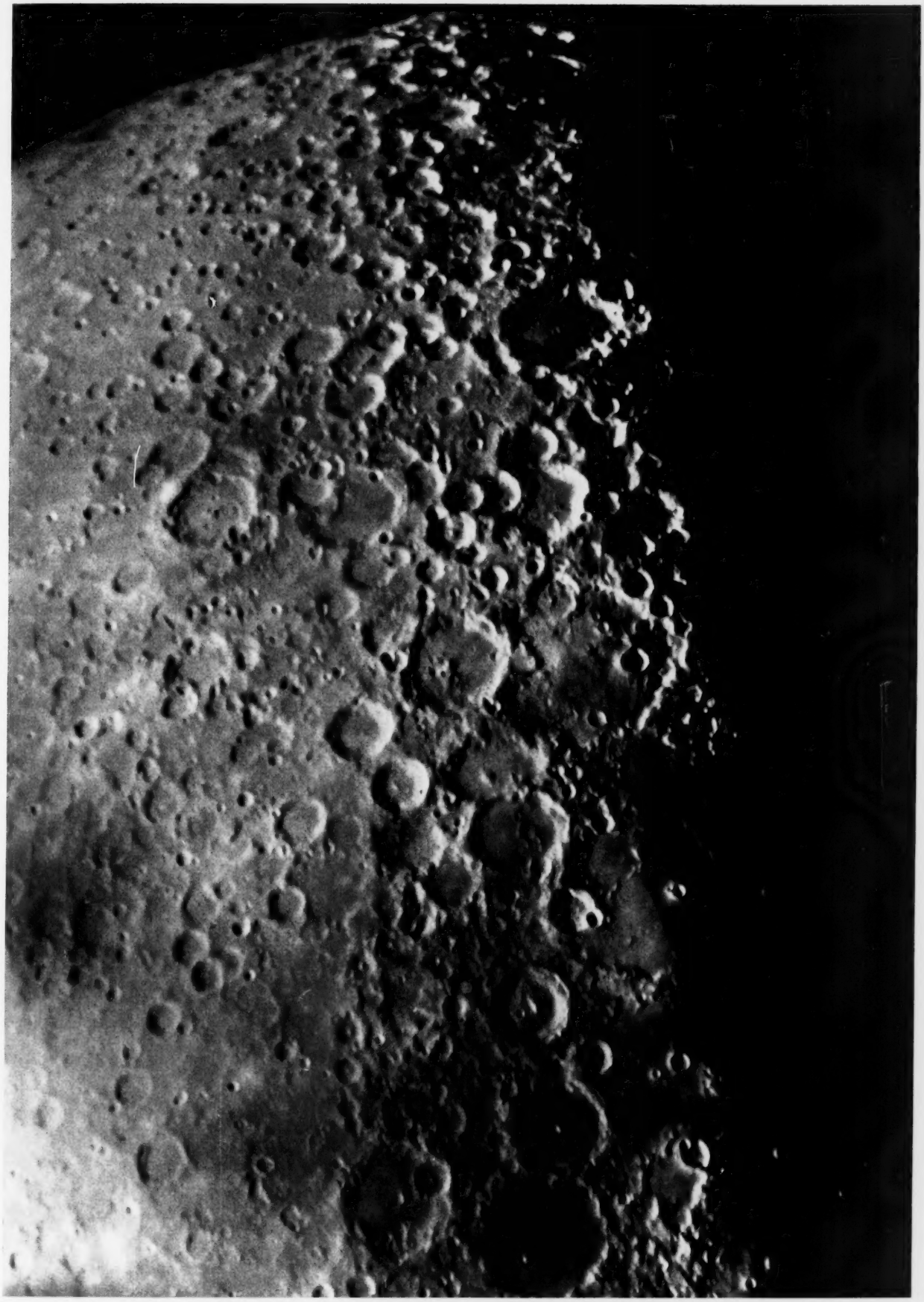
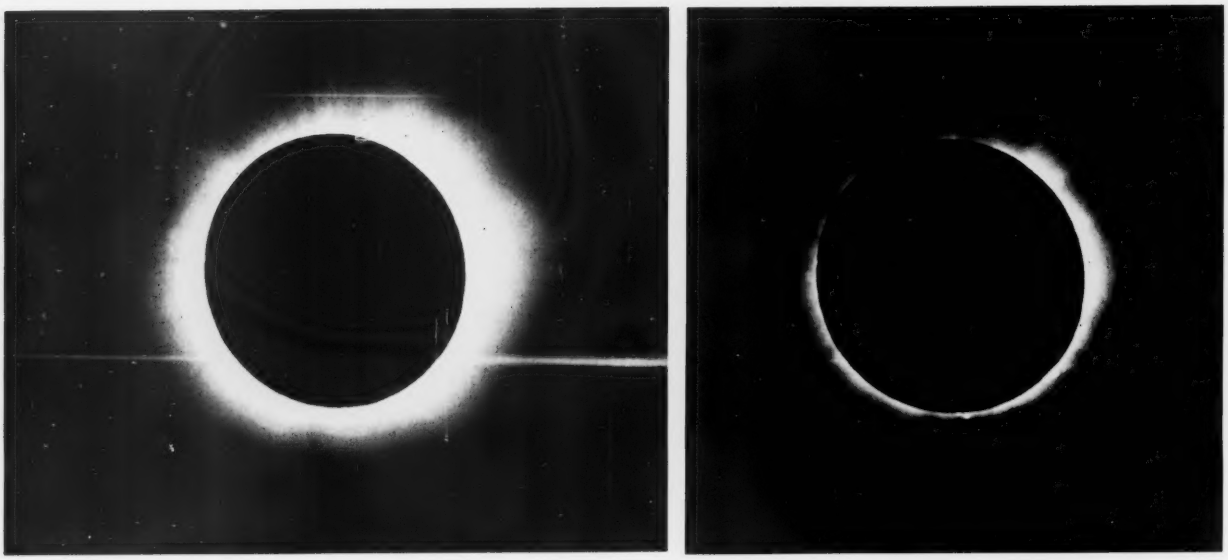
**FACING PICTURE: The mountainous southern part of the moon, photographed by Mr. Kutter on January 28, 1958, at 17:04 UT, 41 minutes after the picture on page 64. A detectable change in lighting has taken place along the terminator, which separates day and night on the moon. The exposure was one-fifth second on Eastman Plus-X film, developed five minutes in Rodinal. Some of the more prominent lunar features are identified in the key chart below.**







**These are different prints from the same negative, taken with the University of Chile's 13-inch astrographic refractor stopped down to 5½ inches. The bright horizontal streaks were caused by reflections inside the telescope. At the left, the photograph was printed to reveal the extent of the corona, the sun's outermost atmosphere. At the right a denser printing shows the inner corona and other details, such as the bright hydrogen prominence at the bottom edge of the sun. University of Chile photographs.**

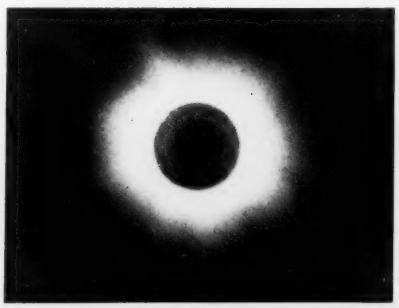
# Eclipse Observations on October 12th

MINGLED SUCCESS and failure have been reported by expeditions to observe the total eclipse of the sun on October 12th, when the moon's shadow traveled from near New Guinea across the Pacific Ocean to South America. This was a notable eclipse for the very few places where the path of totality touched land — a handful of coral atolls in the Pacific Ocean and small parts of Chile and Argentina. Yet it was important to observe, as it occurred during the International Geophysical Year.

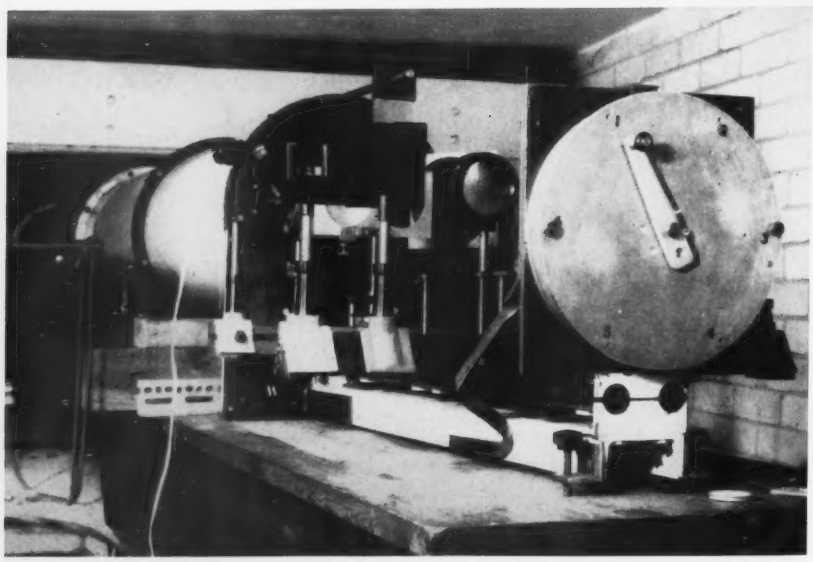
The westernmost expedition was waiting at the tiny island of Atafu, north of Samoa. Dr. H. von Klüber was with a party of English and New Zealand scientists, as described on page 499 of the August issue. He was to make interferometer measurements of spectrum lines in the solar corona, using the equipment pictured here. Soon after the eclipse, Dr. von Klüber sent the following radio message to *Sky and Telescope:*

"Interferometric eclipse observations of Cambridge (England) team on Atafu Island very successful."

Farther east, at the Danger Islands, a thunderstorm blotted out the eclipse for the combined American expeditions. On



**The globular corona typical of sunspot maximum is shown in Luca Erizzo's photograph with a Leica camera and telephoto lens. He had traveled from Italy to Pichilemu, Chile, to see the total eclipse.**

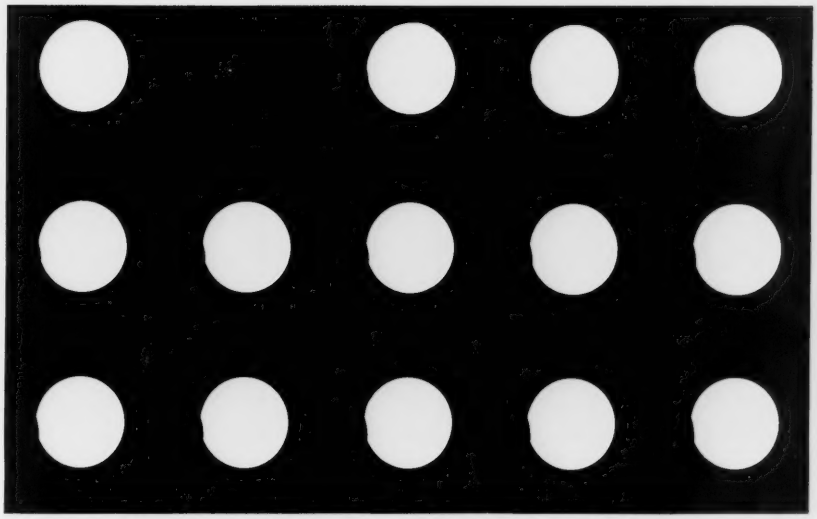


**Dr. H. von Klüber's eclipse interferometer is shown here as set up at Cambridge, England, prior to shipment to the South Pacific. This instrument is an improved version of those he built for total eclipses in 1954 and 1955. Interferometers are used to measure the widths of bright lines in the coronal spectrum, in order to find temperatures in the corona.**

Motu Katava, the shore party of 17 members led by Dr. John W. Evans, Sacramento Peak Observatory, was unable to carry out its program (see *Sky and Telescope*, June and July, 1958, pages 395 and 450). But from the deck of the USS *Point Defiance*, the Naval Research Laboratory group under Dr. Herbert Friedman was able to send up five Nike-Asp rockets to as high as 150 miles, to measure X-rays and Lyman-alpha light from the sun. It is possible that the ground program of the American observers will be repeated at the eclipse of October 2nd, next year, perhaps from an observing station in the Canary Islands.

Some 200 miles to the southeast, Japanese observers were stationed at Suwarrow Island for a broad study of eclipse phenomena. According to a radiogram received from Frank M. Bateson, a well-known South Seas amateur astronomer, the Japanese were successful. But at his home island of Rarotonga, Cook Islands, his own observations of the partial eclipse were incomplete, as they were hampered by clouds.

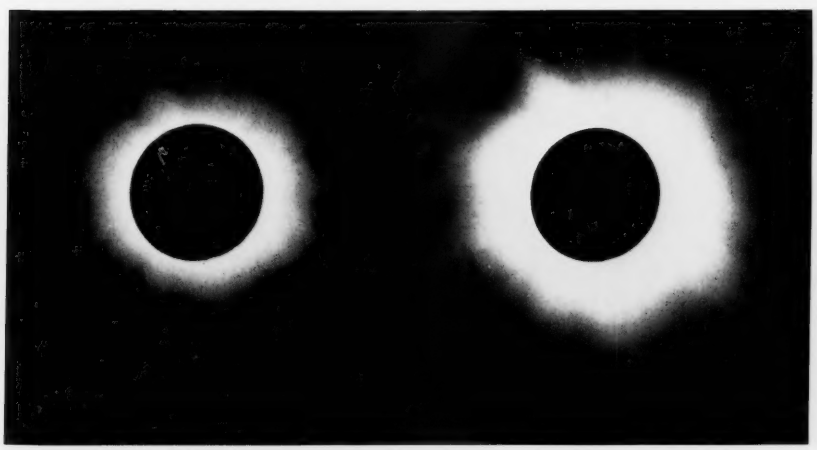
At the eastern end of the eclipse path, excellent weather occurred for over a million eclipse watchers in Chile, with totality taking place shortly before sunset. This was one of the unusual instances where a major astronomical observatory happened to lie inside the path of totality, and full advantage of the opportunity was taken at the University of Chile's observatory at Santiago. Director Federico Rutllant has sent the following report of observations there:



**First contact at a solar eclipse is the instant when the moon first touches the disk of the sun, but it is very hard to observe directly. Measurement of the increasing width of the moon's "bite" on pictures taken in rapid succession allows a precise determination of the moment of first contact. At Santiago Observatory the first image, upper left, was made at 21:35.5 Universal time; the succeeding ones are later by 0.4, 0.7, 0.9, 1.0, 1.2, 1.3, 1.4, 1.5, 1.7, 1.8, 1.9, 2.0, and 2.1 minutes, respectively.**

During the partial stages, a series of accurately timed photographs was taken with the finder of the Carte du Ciel astrographic refractor. Just after first contact took place, exposures were made in rapid succession in order to determine the precise instant of first contact by A. Danjon's chord method. Later, pictures were taken every 10 minutes.

When totality came, the inner corona was photographed by Senora Adelina Gutiérrez with the astrographic refractor itself. Its 13-inch objective was diaphragmed down to $5\frac{1}{2}$ inches for the four-second exposure shown opposite. Other records of the corona were secured by Carlos Torres with a $4\frac{1}{3}$-inch Zeiss refractor, and by Claudio Anguita with an f/5 camera mounted on the 11-inch visual refractor. Jorge Barrera used Leica cameras with telephoto lenses to take black-and-white and color pictures of the corona.



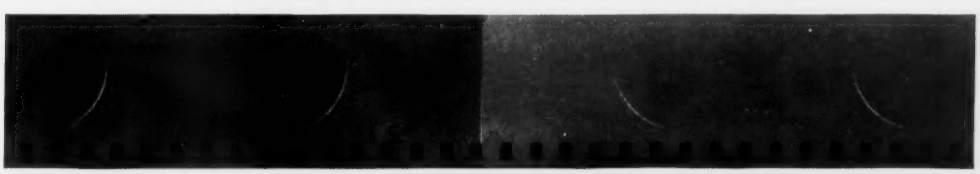
**Fernando L. de Romana of Arequipa, Peru, took these pictures of the eclipse from within the zone of totality in Chile. His exposures were of varying length, to show both detail and the extent of the corona. At the left is a four-second exposure, and at the right the maximum exposure for the outer corona. Note the several long coronal rays.**

Santiago Observatory's largest telescope is its 24-inch Grubb refractor, which was fitted with a Hilger spectrograph for the corona. But the spectrogram obtained was weak, owing to the great focal length of the telescope.

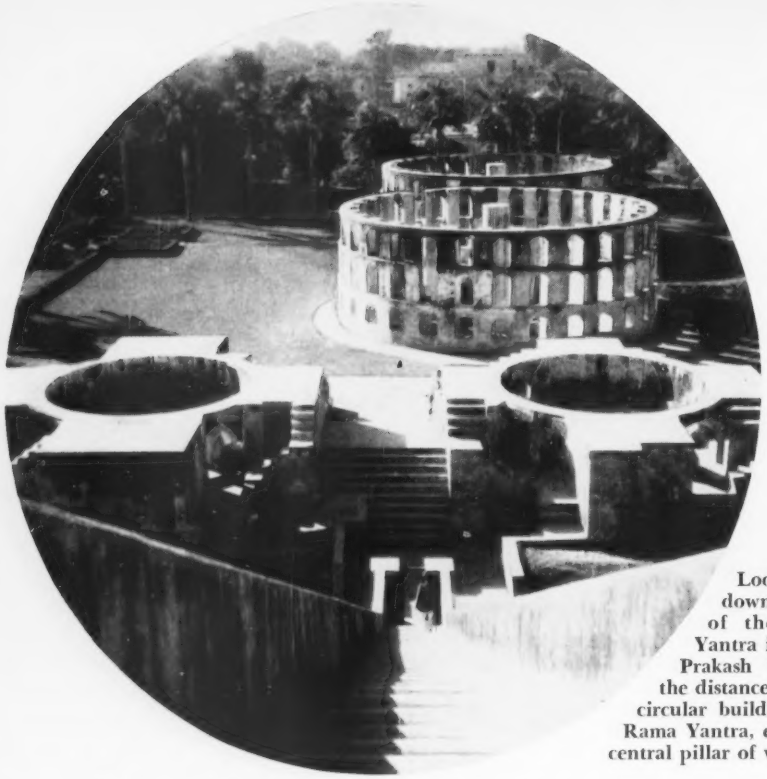
The observatory was about nine miles inside the northern edge of the zone of totality. Yet there the sky became at least as dark as reported by amateurs at Pichilemu, on the central line, where they saw Mercury and Jupiter. At Santiago, Spica was also visible during totality.

Pichilemu is on the coastline, and excellent weather prevailed. Amateurs gathered there from Chile, Peru, Nicaragua, the United States, and Italy, and some of their pictures are shown here. At Arequipa, Peru, Martin S. Burkhead, of the Smithsonian satellite-tracking station, secured photographs of the partial eclipse.

Another observer was Fernando L. de Romana, a veteran of previous South American eclipses, who traveled from his home in Peru to Chile to carry out a photographic program.



**University of Chile photographs of the sun just before second contact, and just after third contact. Universal times are 22:32.0, 32.1, 34.4, and 34.6 (left to right).**



# JAI SINGH
## and His Observatory at New Delhi

K. M. TALGERI

**Looking south down the steps of the Samrath Yantra into the Jai Prakash Yantra. In the distance are the two circular buildings of the Rama Yantra, each with a central pillar of wall height.**

FOR OVER 2,000 years astronomy has been cultivated in India. The traditional Hindu system of astronomy, *Surya Siddhanta*, is of unknown origin, but it was influenced by the Graeco-Babylonian school of astronomy, which became known in India after the conquests of Alexander the Great. During the dark ages, the countries of the Near East and India became the custodians of classical science.

More than a century after the invention of the telescope, astronomers in many countries of the world, practically isolated from their European contemporaries, used naked-eye methods of observing the sun and stars to obtain time and position. Among the greatest of such astronomers was the Maharaja Jai Singh, who in 1724 built the famous Jantar Mantar at New Delhi, which the American novelist Lillian Smith has called one of the most fascinating places on earth.

**Besides the New Delhi observatory, Jai Singh built similar installations at four other sites. The inset shows the area covered by the detailed map.**

Famous as an astronomer and mathematician, Jai Singh II was ruler of the state of Jaipur, and in 1728 founded its capital city of the same name, about 150 miles southwest of New Delhi. As an erudite scholar he had mastered the Surya Siddhanta, and he studied Ptolemy's monumental work, the *Almagest*. He also read the 13th-century translation, by the Persian astronomer Nasir Ul Din, of Euclid's elements of geometry.

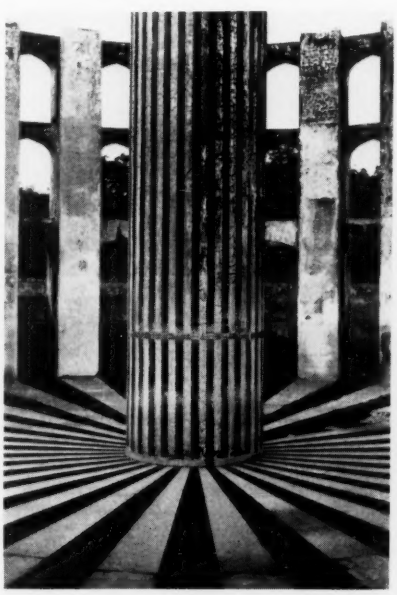
Among the Moslem astronomers of earlier days who inspired Jai Singh were Ulugh Beg and his assistant Jamshed el Kashi. Ulugh Beg was the grandson of Timur the Lame and ruler of Samarkand, where he erected an observatory in the year 1425. His astronomical tables superseded those of Ptolemy, and were the basis of Jai Singh's work.

The latter's passion for astronomy became so great that he sent emissaries to distant lands to bring back scientific knowledge. Through the Jesuit missionaries in India, he heard echos of the discoveries of Copernicus, Tycho Brahe, Kepler, Galileo, and Newton, but this did not change his preference for traditional naked-eye observing methods, with instruments of enormous size to achieve greater accuracy.

One of the scholars Jai Singh invited to his kingdom was the Portuguese physician-astronomer Don Pedro de Sylva, later known as Hakim Martin. Even to this day his descendants live in Jaipur, and a street in that city bears his name. From such sources the maharaja learned trigonometry and the use of logarithms, and acquired copies of European astronomical tables by John Flamsteed and Philippe de La Hire.

Jai Singh was much dissatisfied with the Indian calendars of his day, and resolved to provide a better basis for them from new observations. This led him to construct five astronomical observatories, at New Delhi, Jaipur, Banaras, Ujjain, and Mathura. Guided by Moslem rather than European example, his instruments were gigantic masonry structures for naked-eye sightings of celestial bodies.

The first of these observatories was built at New Delhi, now India's capital, in collaboration with Pandit Jagannath. This Telugu Brahmin was well versed in Hindu and Moslem astronomical lore, and highly proficient in Sanskrit, Arabic, and Persian. The New Delhi observatory is known as the Jantar Mantar, from the Sanskrit word *yantra*, instrument. It consists of a number of structures, the



**The horizontal shafts of the Rama Yantra, radiating from the central pillar, bear markings of the altitude scale. An observer can walk between the shafts and sight to an object from the markings at eye level.**

Samrath Yantra, the Rama Yantra, the Jai Prakash Yantra, and the Misra Yantra. The second and third of these are in pairs.

In the center of the observatory area is the Samrath Yantra, an enormous equatorial sundial whose gnomon, pictured here, casts its shadow on an arc of masonry which is marked in hours, minutes, and seconds. There is a long flight of steps leading to the top of the gnomon, providing a fine view of the other instruments of the observatory.

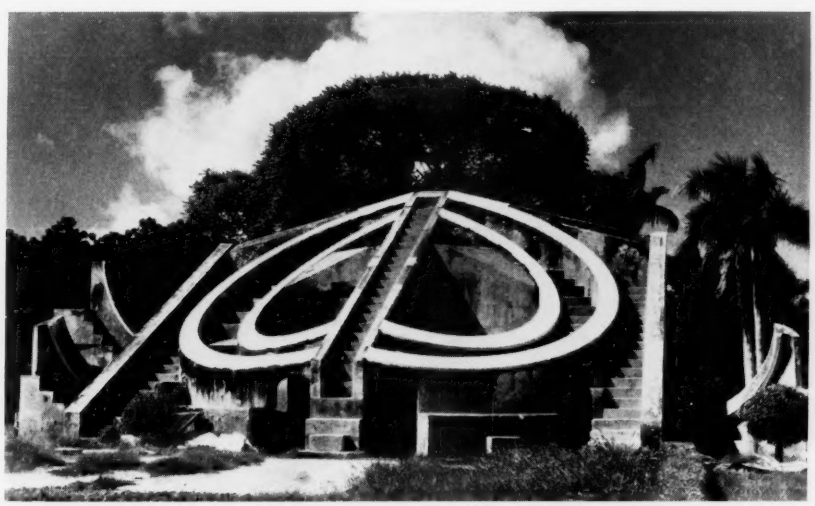
The Rama Yantra consists of two circular buildings, each with a central pillar from which shafts radiate horizontally to the outer wall. The azimuth of a celestial body is determined by its direction when sighted across the top of the pillar, and to measure altitude an observer stands either in the wall or in the slots between the shafts, sighting to the object across the top edge of the pillar.

Altitude graduations are marked on the inside of the wall, starting with 0° at the top, for an object on the horizon (as seen by an observer at the top of the wall), and reaching 45° where the wall and shafts join. For altitudes of 45° to 90°, the scale is marked on the shafts themselves, increasing to 90° (for an object in the zenith) at the base of the pillar.

Inasmuch as the observing slots and shafts are partly obstructed by the masonry itself, two such instruments had to be built, the openings in one corresponding to the masonry supports in the other.

For a similar reason, the third instrument is also in two parts. It is the Jai Prakash Yantra, also known as the Bowl of Berossus, after the Babylonian astronomer of about 280 B.C. To afford access for the observer, the solid parts of one building correspond to the vacant spaces of the other. Each hemispherical cavity is plastered and polished, with lines to represent the meridian, equator, and circles of altitude and azimuth. The rim, which denotes the horizon, is divided in degrees and minutes. Exactly north-south and east-west over the bowl are stretched cross wires that carry at their intersection a piece of perforated metal. The position of the sun in the sky can be found by locating its pinhole image on the bowl.

**A view northward up the steps of the huge gnomon of the Samrath Yantra. The circular picture on the facing page was taken from a point high on these steps. At the left is the Niyat Chakra Yantra, shown in more detail below. The author provided all of the pictures with this article.**



**A closeup of the Niyat Chakra Yantra, used for observing the sun. This is part of the Misra Yantra, the most intricate instrument at the Jai Singh observatory.**

The Misra Yantra is the most complex of the New Delhi instruments, consisting of four parts. Of these the most interesting is the Niyat Chakra Yantra, for observing the sun. As seen in the picture, there are four semicircular arcs, whose common center is halfway up the stairway of the gnomon. When the shadow of a rod that may be mounted at this center falls in turn on one of the arcs, the moment is local apparent noon at one of four observatories in widely separated lands. The arc farthest right, for example, is supposed to show Greenwich noon.

Observations with these massive instruments began in the year 1729, and it was intended to compile tables of the positions of the planets, but these were never

published. According to the German historian Ernst Zinner, Jai Singh said that from seven years of observation the lunar tables of La Hire were in error by as much as half a degree, and that the eclipse predictions from them were up to six minutes off.

The maharaja's second observatory, at Ujjain, probably dates from the years 1728-34. Apparently, this location was chosen because it had been used as the zero meridian of longitude by medieval astronomers in India. No observations seem to have been made at that observatory, however, nor at the one Jai Singh erected at Banaras in 1737. The Jaipur observatory, built in 1734, is well known and still standing. The fifth of the series, at Mathura, was never finished and was demolished later in the 18th century.

Today the Jantar Mantar at New Delhi remains an impressive monument to the astronomical interests of Maharaja Jai Singh II.

# NEWS NOTES

## *LITHIUM IN THE UPPER ATMOSPHERE*

At Adelie Land, close to the Antarctic Circle, French IGY observers have been studying the spectrum of the aurora with a large grating spectrograph. During spring and fall, when the sun is not far enough below the horizon for auroral work, they have used the same equipment to investigate the spectrum of twilight.

In this way, they have detected a red emission line with a wave length of 6708 angstrom units, seemingly identical with the resonance line of lithium whose laboratory wave length is 6707.84 angstroms. This finding, reported in the September 15, 1958, issue of *Comptes Rendus* by J. Delannoy and G. Weill, demonstrates the existence of traces of free lithium in the earth's upper atmosphere.

The yellow lines of sodium, an element chemically related to lithium, have long been known in the spectrum of twilight, but there is much uncertainty whether this upper-atmosphere sodium is of meteoric origin, or whether it is from ocean salt that has diffused upward and become dissociated by sunlight. The French investigators suggest that other metallic lines, for example those of potassium, should also be observable in twilight spectra.

## *INSTITUTE OF SPACE SCIENCES*

The University of Cincinnati will open an institute of space sciences in September, 1959, offering a three-year graduate curriculum leading to a master of science degree and then to a Ph.D. in dynamical astronomy. Dr. Paul Herget, director of Cincinnati Observatory and scientist in charge of the Vanguard computing center in Washington, D. C., will head the institute.

The continuing need for personnel trained in orbit and observation problems in the many missile and artificial satellite programs has prompted establishment of the school. The U. S. Navy has already awarded the university a $54,000 contract for work on artificial satellite problems.

## *GREEN BANK DEDICATION*

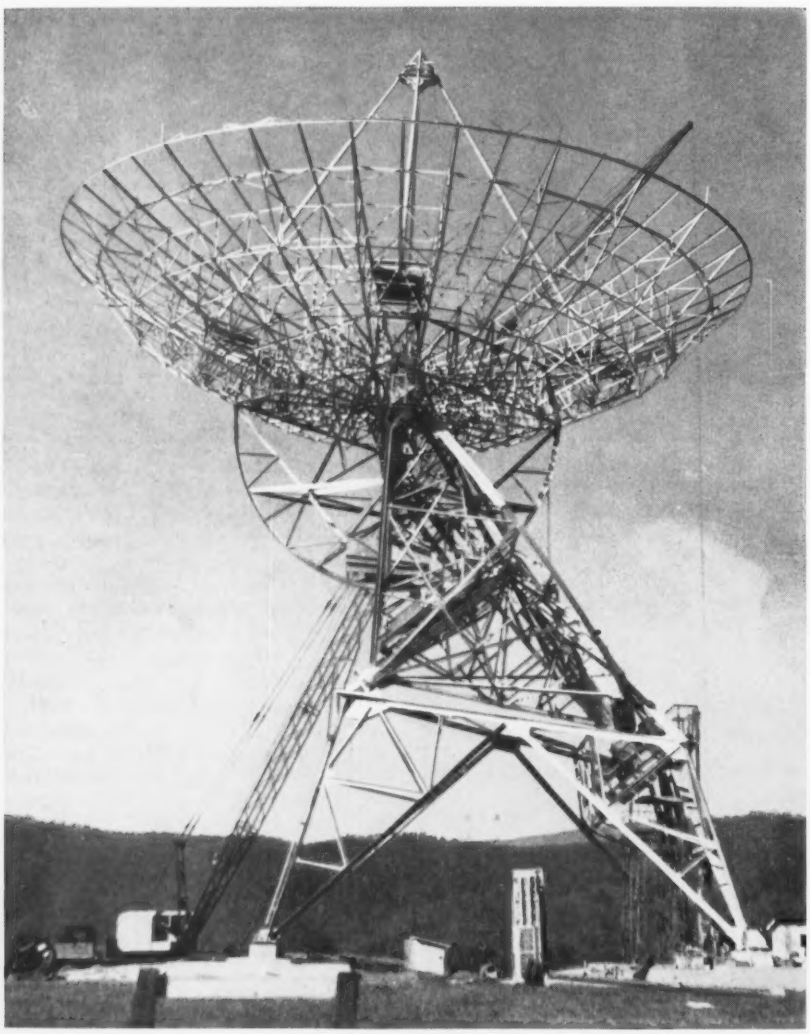
At Green Bank, West Virginia, formal ceremonies on October 16, 1958, marked the dedication of the 85-foot radio telescope of the National Radio Astronomy Observatory. This new research institution, which is operated by Associated Universities, Inc., is being constructed with financial support from the National Science Foundation. Later the observatory is to have a radio telescope of 140 feet aperture (see page 398, July, 1956).

The 85-foot instrument will be known as the Howard E. Tatel telescope, in honor of a Carnegie Institution geophysicist who died in 1957. Dr. Tatel had been very active in the development of special equipment for radio astronomy, and was a principal contributor to the design of the new telescope at Green Bank.

## *INFRARED PHOTOGRAPHY*

A new method of taking pictures in infrared light of wave lengths between 0.7 and 2.5 microns has been devised by two scientists at New York University. H. Kallmann and J. Rennert use a phosphor — zinc and cadmium sulfides in a plastic film — which is first sensitized by light from a mercury lamp.

After the phosphor "plate" has been exposed to infrared radiation from the object being photographed, the latent image is developed by uniform irradiation with either low-intensity ultraviolet or near-infrared radiation. This causes the



**The new radio telescope of the National Radio Astronomy Observatory during the final stages of its construction. The polar-axis assembly is essentially conical, with a large ring bearing used for setting and tracking. Above this is the declination-axis assembly, which carries a square frame to support the paraboloidal antenna, 85 feet in diameter.**

## IN THE CURRENT JOURNALS

ATMOSPHERES OF OTHER PLANETS, by Seymour L. Hess, *Science,* October 10, 1958. "I shall . . . deal only with Venus, Mars, and Jupiter. We shall see that physical conditions and the nature of the atmospheres of these three vary so greatly that each represents a unique scientific puzzle."

phosphor negative to glow, giving an image which can be copied by ordinary photography.

One advantage of the method for possible astronomical applications is that the operations of sensitizing, exposure, and development need not be made in quick succession, but can be separated by weeks. Many different phosphor compositions can be used, according to the article in the November issue of the *Journal* of the Optical Society of America.

### *NEW CANADIAN TELESCOPE*

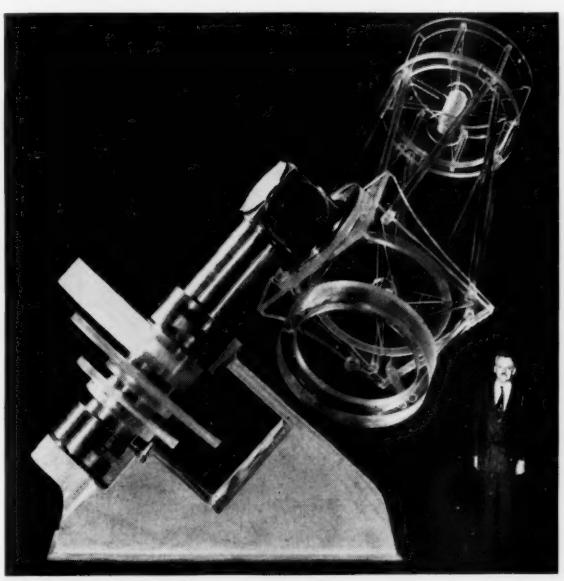
A reflector with a 48-inch mirror will go into operation at the Dominion Astrophysical Observatory, Victoria, British Columbia, within the next two or three years. It is to supplement the 72-inch telescope there, for that instrument now has a very heavy observing schedule. The 48-inch is under construction by Grubb Parsons in England, and is expected to be delivered in the first half of 1961.

The new mirror's focal length is 192 inches, f/4, but the optical system will provide three f/18 foci, one at the usual Cassegrainian position, the other two near the intersection of the polar and declination axes. An f/30 coude focus will also be available. The polar axis of the single-pier modified English-type mounting terminates just above its intersection with the declination axis. The semi-cylindrical counterweight is offset to the lower part of the polar axis, where it swings through the gap in the base of the mounting.

**A picture taken during construction of the 48-inch telescope building. The ground floor is nine feet high, and includes the coude room (right foreground).**

The instrumentation has been described by Andrew McKellar, of the observatory staff. At one of the f/18 foci, a photoelectric photometer will be permanently mounted, spectrographs and experimental equipment at the others. Provision has been made for possible future work at the prime focus. The coude spectrographs will be modeled after those at Mount Wilson and Palomar Observatories (*Sky and Telescope,* September and October, 1957), but the coude room is not placed at the southern end of the polar axis, nor sloped at the angle of latitude, as in many other observatories. Instead, the f/30 beam will be intercepted six feet short of its focal point and reflected horizontally eastward into the coude room, which measures 25 by 24 feet.

Construction of the instrument's 32-foot dome began last February, and is expected to be completed shortly. The shutter system will be of the up-and-over type, like that for the 120-inch reflector at Lick Observatory. The new building is several hundred yards north of the 72-inch reflector and at approximately the same height above sea level.



**This model shows the relative scale of the 48-inch mounting and tube, the truncated polar axle, and the gap in which the driving gears turn. The counterweight (just above the largest gear) swings through this gap when the instrument is above the polar axle. The tube is supported from one side only, the declination axle being represented by a very large ring bearing. A hole in its center admits the light beam to the hollow polar axle, where two of the f/18 foci are located. Dominion Astrophysical Observatory photographs.**

### *SEARCH FOR BRIGHT VARIABLE STARS*

About a quarter of all naked-eye stars are appreciably variable in brightness, it may be concluded from a photoelectric survey carried out by G. Jackisch at Sonneberg Observatory, in East Germany. He chose a sample of 151 stars, all brighter than magnitude 4.5, that passed near the zenith of his observatory. With a photoelectric photometer attached to a 14-inch reflector, he secured for each star an average of 12 observations, with a mean error of $\pm 0.020$ magnitude for a single measure.

From a careful statistical analysis of the spread of the measures for each star, he concluded that 36 of his 151 program objects were actually variable. Additional observations were then secured for some of these stars, showing that 21 Leonis Minoris varies by 0.09 magnitude in a three-hour period, and Mu Persei by 0.08 in a cycle of about two hours and 20 minutes. Xi Ursae Majoris and Tau Geminorum vary by 0.04 and 0.06 magnitude, respectively.

Dr. Jackisch reported these results to the International Astronomical Union at Moscow in August.

A dozen years ago, on this Lick Observatory photograph of the diffuse nebulosity Messier 8, Harvard astronomer Bart J. Bok found numerous globules — compact dark dust clouds that are stars in the making. Some of them are indicated by the arrows.

# Some Possible Evidence of Evolution in Individual Stars


OTTO STRUVE

*Leuschner Observatory*
*University of California*


MODERN astronomical research puts much emphasis on problems of stellar and galactic evolution. Astronomers are generally agreed that the broad picture of the life history of a star is along the following lines:

The star is born somewhere inside a normal galaxy, which contains about equal amounts of material in the form of stars and tenuous gas, with a slight admixture of solid particles — dust or crystals — whose diameters are of the order of $10^{-5}$ centimeter. The stars originate within the gaseous nebulae as a result of contraction. Against the faintly luminous background of a diffuse nebula we often observe dark *globules,* cloudlets dense enough to be gravitationally stable against the disrupting tidal forces of the galaxy as a whole or of nearby stars.

Each globule continues to contract, and becomes a *protostar* when it is visible by its own radiation. How long this contraction stage lasts depends on the mass of the globule. For a mass equal to the sun's, about 500 million years are needed, whereas stars 20 times as massive as the sun have a contraction stage lasting only about half a million years.

The contraction stops when the nuclear processes in the star's interior generate enough energy to balance the escape of radiation from the surface. The star is then of such a temperature and luminosity that it is on the main sequence of the Hertzsprung-Russell diagram, where it remains as long as there is an adequate supply of nuclear fuel, in the form of hydrogen. For the sun, this equilibrium condition may last about $10^{10}$ years, while for a very massive star it may be of the order of one million years or even less.

After the hydrogen fuel has become partially exhausted by conversion into helium, the isothermal core of the star again begins to contract. The energy released by this process tends to inflate the outer layers of the star, which grows in radius while its surface temperature and mean density decrease. Thus, the star becomes a red giant. Its evolutionary track in the H-R diagram runs from the main sequence toward the right. As the center of the star grows hotter, helium begins to fuse into carbon and more nuclear energy becomes available.

Finally, the radius of the star begins to shrink, and its surface temperature and mean density increase. In its evolutionary track in the H-R diagram, the star approaches the main sequence, crosses it, and ultimately drops into the region of the extremely dense white dwarfs. In this change all massive stars undergo more-or-less catastrophic explosions, resulting in loss of material.

Most of these results have been obtained from observations of star clusters

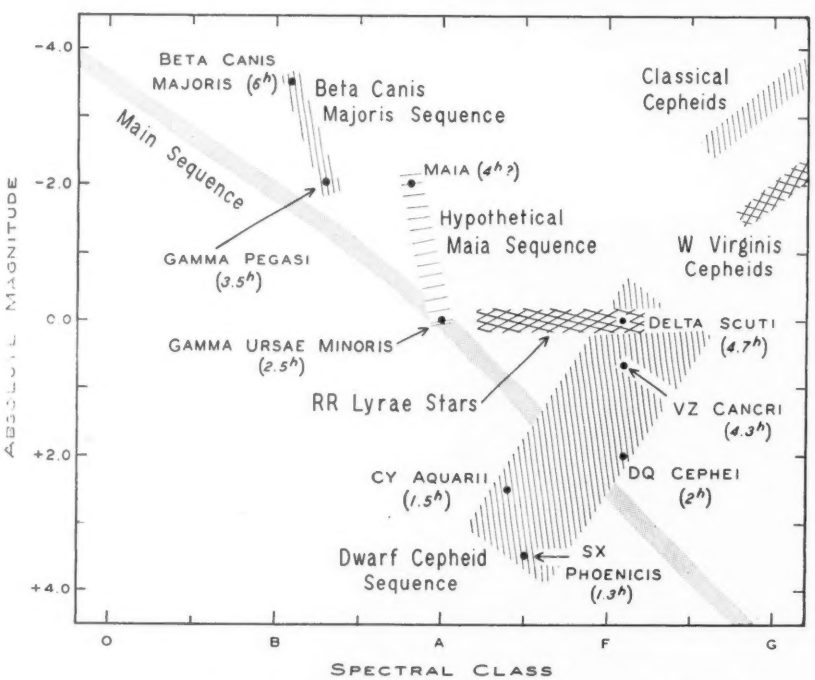


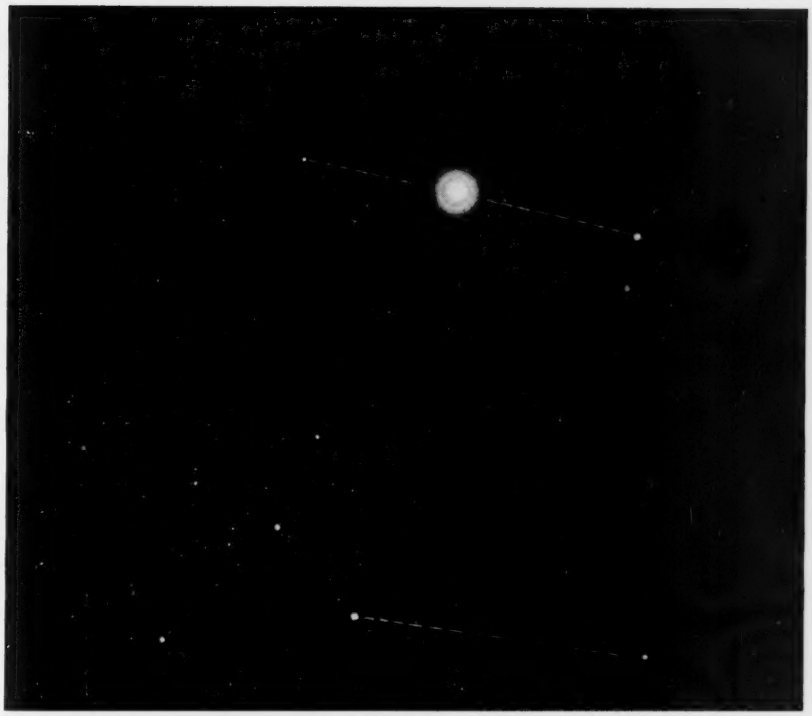

**Fig. 1. In this schematic Hertzsprung-Russell diagram, the ordinary nonvariable dwarf stars populate the main sequence, which runs diagonally. Several sequences of pulsating variable stars are indicated, and the names and periods of some individual variables.**

of different ages. It is reasonable to assume that a young star group, like the Double Cluster in Perseus, will after a long interval be similar to the Pleiades or Hyades, which we now recognize as old. We have not actually observed evolutionary changes in individual stars, however, for decades or centuries are too short to reveal measurable changes in luminosity or surface temperature.

Evidently the detection of evolutionary changes in single stars would mark a great advance. There are three kinds of phenomena that give some promise in this respect. First, there are catastrophic or continuous rapid changes in mass, occurring in supernovae, novae, SS Cygni variables, P Cygni stars, or the central stars of planetary nebulae. Second, there may be evolutionary changes in the orbital periods of close binary stars. Third, and of interest to us in this article, there may be changes in the periods of pulsation of certain variable stars, such as those of the Beta Canis Majoris type.

These are hot blue stars with small rhythmic changes in brightness and radial velocity. Their periods of pulsation range from roughly $3\frac{1}{2}$ hours for Gamma Pegasi to six hours for Beta Canis Majoris itself. The spectral types range from *B*3 for the shortest periods to *B*0 for the longest. The location of this sequence in the H-R diagram is shown in Fig. 1, together with several other sequences of pulsating variables.

Stars of this type almost certainly form a sequence of objects with different masses. Gamma Pegasi, near the bottom of the sequence, has a mass of about five suns; Beta Canis Majoris, at the top, almost 10. Since we believe that stars in this stage of evolution are developing without significant change in mass, it is unreasonable to suppose that Gamma Pegasi will in time resemble Beta Canis Majoris. In other words, the sequence is not an evolutionary track. (The assumption that it is one was made in my paper mentioned in *Sky and Telescope*, page 325, June, 1955, but is now known to be incorrect.) Instead, the evolutionary tracks of individual Beta Canis Majoris stars run nearly horizontally from left to right in the Hertzsprung-Russell diagram.



**The constellation Canis Major is now visible in the winter evening sky. The line leading to the right from the much overexposed image of Sirius ends at Beta Canis Majoris, the brightest variable of the type named after it. Harvard Observatory photograph.**

The most famous member of the sequence is the 6th-magnitude star BW Vulpeculae (also known as HD 199140). Its variability in radial velocity was discovered by R. M. Petrie, and the spectrum has been investigated by him and G. Odgers at Victoria, and by me at Mount Wilson Observatory. In 1938, C. M. Huffer found photoelectrically that the range of the star's light curve is about 0.2 magnitude, large for a variable of this sequence.

According to Petrie and all more recent observers, the period of BW Vulpeculae is increasing steadily by about three seconds per century. Although this is a small change, it is well established by about 30 years of observation. The average period of BW Vulpeculae is four hours 49 minutes, or roughly $1.7 \times 10^4$ seconds, so the star runs through about 2,000 cycles annually. We can time individual maxima with a precision of about one minute. Hence observations during a single year can fix the period to within $60/2{,}000 = 0.03$ second. Thus, a rate of change of three seconds in 100 years is relatively easily obtained from observations stretching over a few decades.

Several others of the Beta Canis Majoris stars have been found to have increasing periods, though at smaller rates. The period of Sigma Scorpii is lengthening by 2.3 seconds per century, and that of Beta Cephei by 1.2 seconds. For some other stars of this type, the periods are growing by only 0.1 or 0.2 second in 100 years. Perhaps we may assume that a typical variable of the Beta Canis Majoris class has a period increasing by one second per century.

To interpret this fact, let us first consider Fig. 2, in which are drawn a number of slanting curves representing equal stellar radii. These are obtained from the relation between the luminosity of a star and its surface area and energy output per unit area, in the following manner:

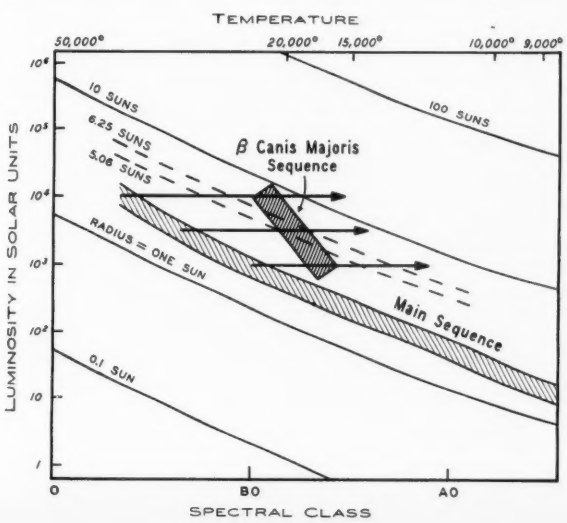



**Fig. 2. In this portion of a schematic H-R diagram, arrows mark the evolutionary tracks of three massive stars, which temporarily become pulsating Beta Canis Majoris variables as they cross the shaded rectangle. The curves slanting toward the lower right represent different stellar radii, all the Beta Canis Majoris variables being larger than the sun.**

If the radius of a star is $R$ and its surface temperature is $T$, its area is $4\pi R^2$, and each square centimeter of this area radiates into space $\sigma T^4$ ergs per second, in accordance with Stefan's law. The bolometric luminosity (that is, the radiation summed over all wave lengths) is

$$L = 4\pi R^2 \sigma T^4.$$

It is convenient to express $L$ in terms of the sun as unity; similarly, $R = 1$ for a star of the same radius as the sun.

Consider first only stars the same size as the sun. If such a star had a temperature of 10,000°, its luminosity would be

$$L = 4\pi\sigma(10{,}000)^4,$$

while for the sun, whose temperature is 6,000°,

$$1 = 4\pi\sigma(6{,}000)^4.$$

Dividing the first expression by the second gives for the star

$$L = (10{,}000/6{,}000)^4.$$

In this manner we find a series of points for different values of $T$ but all for $R = 1$, giving the curve with this label in Fig. 2.

The corresponding curve for stars with 10 times the sun's radius is easily obtained, since the luminosity is proportional to $R^2$. We simply displace every point of the original curve upward by a factor of 100 in the value of $L$.

On drawing such curves in the H-R diagram, we see at once that the stars at the upper end of the main sequence are four or five times larger than the sun, slowly decreasing to the solar radius at spectral type G0. The Beta Canis Majoris sequence consists of stars whose radii are about five suns at the lower end, for periods of around 3.5 hours, and about 10 suns for the six-hour stars at the upper end. Therefore, the stellar *volumes* at top and bottom are in the ratio of $(10/5)^3 = 8$.

As we have already seen, the masses at the upper and lower ends of the Beta Canis Majoris sequence are 10 and five times the sun's, respectively — a ratio of two to one. The mean density of a star is its mass divided by its volume. Hence the mean densities at the top and bottom of the sequence are in the ratio

$$\varrho_t/\varrho_b = 2/8 = \tfrac{1}{4}.$$

This is very nearly equal to the inverse square of the ratio of the corresponding periods:

$$(P_t/P_b)^{-2} = (3.5/6.0)^2 = 1/3.4.$$

We can draw a very important conclusion from this: The variables of the Beta Canis Majoris sequence obey the fundamental law of pulsating gas spheres: $P^2\varrho = \text{Constant}$. In other words, the periods of the individual stars of this type are inversely proportional to the square roots of their densities. This law has been found to apply to all other known groups of periodic intrinsic variable stars. Thus we see that as a star moves along the evolutionary track shown by an arrow in Fig. 2, it begins to pulsate when it enters the left edge of the domain of the Beta Canis Majoris stars, and continues to pulsate until it passes the right edge of this region.

It is true that we have tested the application of the pulsation law only by comparing stars of different masses. We do not know enough variables of the same absolute magnitude but different surface temperatures to determine the width of the sequence. We know only that the width is small.

The evolution we are considering — a horizontal track across the Beta Canis Majoris domain — occurs without any significant change in mass. (Even converting all available hydrogen in a star to helium would reduce the mass by less than one per cent.) The radius does change, however; it is 5.06 suns when the star enters the band of variables and 6.25 suns when it leaves. This changes the volume of the star by a factor $(6.25/5.06)^3 = 1.86$. Since the mass stays the same, the density decreases by the same factor of 1.86.

How much does this alter the period of the variable? The fundamental pulsation law $P^2\varrho = \text{Constant}$, which we have seen holds for the Beta Canis Majoris stars as a group, may also be applied to an *individual* star whose density is changing. At the point of entering the band, the period is $P'$ and the mean density $\varrho'$, and at the exit point they are $P''$ and $\varrho''$, respectively. Writing the pulsation formula twice, for each of these points, and eliminating the constant, we find

$P''/P' = (\varrho'/\varrho'')^{\frac{1}{2}} = 1.86^{\frac{1}{2}}$, or nearly 1.4.

Suppose that the period of the star when near the central line of the sequence is 17,000 seconds. The final period would be a little longer than this, the initial period a little shorter. Computation shows that at the entrance point the period is about 14,000 seconds, or roughly $3\frac{3}{4}$ hours, while at the end point it is 21,000 seconds, or $5\frac{3}{4}$ hours.

Hence, if the band is as wide as we have assumed, there should be a considerable spread in period, not only along the central line of this sequence but across it. This effect has not been observed yet, and perhaps the sequence is narrower than we have supposed. Photoelectric observations of the kind made by B. Strömgren and described in last month's article should give us that information.

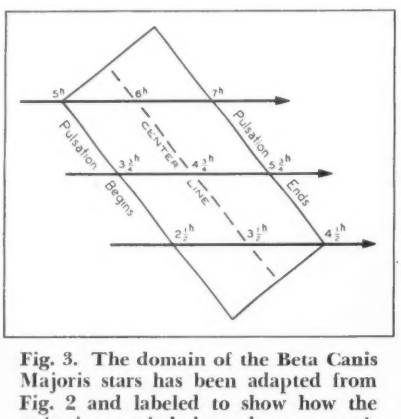



**Fig. 3. The domain of the Beta Canis Majoris stars has been adapted from Fig. 2 and labeled to show how the pulsation period depends on a star's location in the sequence. Apparently there is an evolutionary increase in period as stars move along the tracks indicated by arrows.**

But the actual width of the band need not be known to calculate the rate of evolution suggested by the increase in period. We merely state that *if* the stars pulsate as they cross the band, their periods would increase by about 7,000 seconds in the meantime. Then, if the period of a typical Beta Canis Majoris star is increasing by one second per century, it takes $7{,}000 \times 100$ years — on the order of a million years — for the star to traverse the band. If the band is narrower, the change in stellar volume is smaller and so is the total change in period; the star would need less time to run across the band.

Our result — somewhat less than a million years for an average Beta Canis Majoris variable to evolve from type *B*1 to *B*3 — can be compared with the theoretical time scale obtained by R. J. Tayler in 1954, about 60 million years. The discrepancy is large, but perhaps not insurmountable.

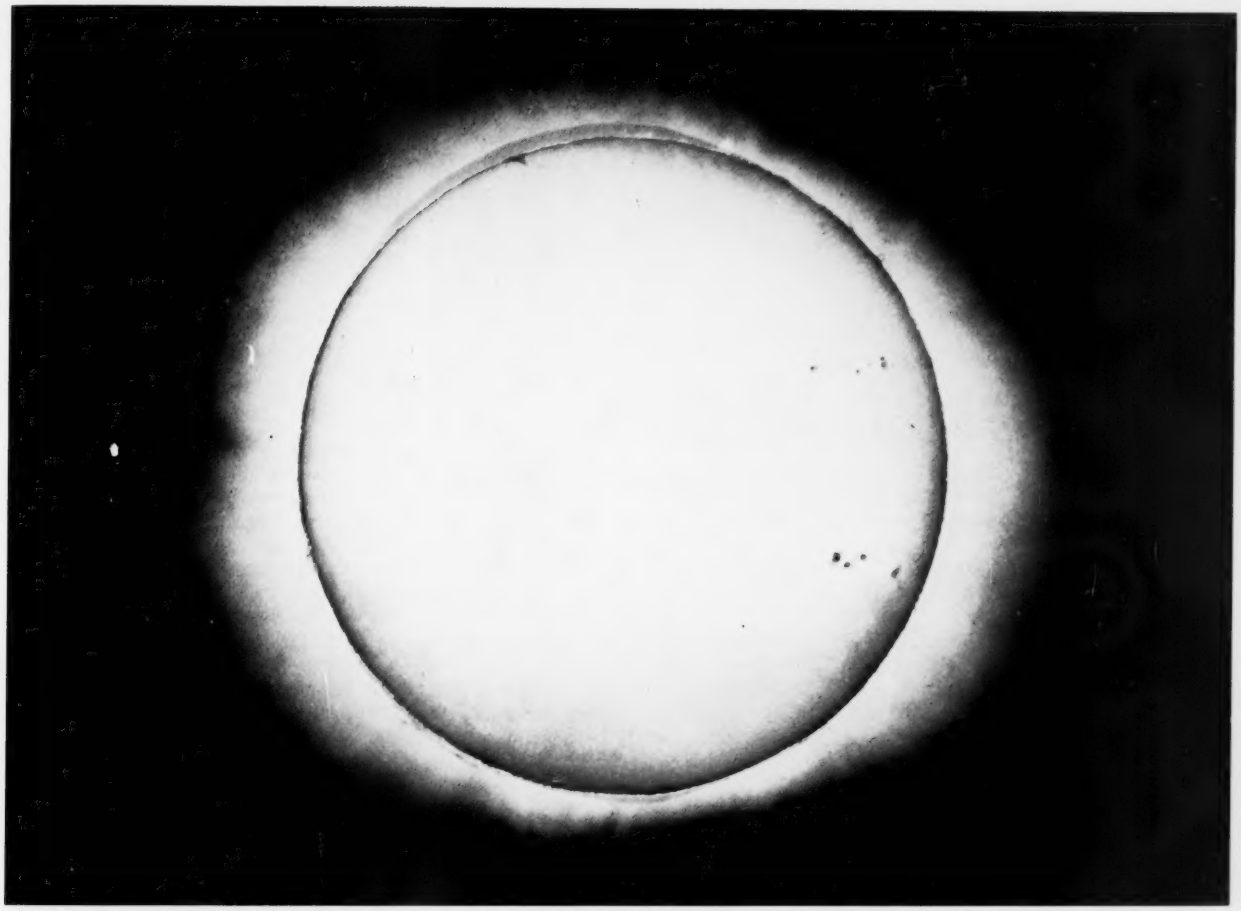
In the first place, Tayler's figure is for time starting at the main sequence, while our variables are already well off the main sequence when they first enter the Beta Canis Majoris domain. The evolution must proceed more rapidly after the star has departed one or two spectral subdivisions from the main sequence.

Furthermore, we are concerned with more massive stars than those discussed by Tayler, and the rate of evolution is faster the more massive the star. Finally, we have assumed that the evolutionary track is horizontal in the H-R diagram. If it actually curves slightly upward, as Tayler thinks, this would increase the interval of time during which the star would pulsate.

Moreover, there are other indications that the time scale computed from theoretical models is too long. For example, A. Blaauw's work on expanding associations of *O*- and *B*-type stars indicates ages of the order of one million years for stars still on the main sequence or very near it. The subsequent evolution of such a star away from the main sequence might then be expected to take even less time.

The assumptions underlying the theoretical calculations may not be fully realized in the hottest stars. One possibility is that these stars lose an appreciable amount of mass by corpuscular radiation. The spectra of *O*-type stars show that they are highly unstable, shooting clouds of gas from their surfaces into space. Perhaps this process is significant for the *B*-type stars also. If so, the mean density

*(Continued on page 86)*



**A composite picture of the sun, showing the photosphere, sunspots, prominences, and the inner corona, as they would appear together if the enormously bright main body of the sun did not drown out light from the much fainter outer envelope. To obtain this effect it is necessary to superimpose a photograph of the sun's disk on a corona picture, taken either with a coronagraph or at a total solar eclipse. This composite was first published at Harvard Observatory over 20 years ago.**

# Solar Research Reported at Moscow

ORREN C. MOHLER, *McMath-Hulbert Observatory, University of Michigan*

ONE of the features that distinguished the recent assembly of the International Astronomical Union from its predecessors was the enormous increase in the number of solar astronomers present, and in the number of papers they gave. At earlier meetings the members of all solar commissions could gather in a room of moderate size, but at Moscow more than 50 persons attended the meeting of even the smallest commission.

There was a similar abundance of papers. With only one exception, time was requested for reading more than 20 reports at each three-hour session. The printed schedule listed 80 hours for presenting and discussing matters relating to the sun during the nine days of the assembly. In view of these circumstances, a complete story of the solar program cannot be given here; it can only be hoped that few major points have escaped notice.

A. Dollfus (France) reported on the cooperative attempt with D. E. Blackwell and D. W. Dewhirst, both of England, to photograph the fine granular structure of the photosphere from a manned balloon at an altitude of about 20,000 feet. M. Schwarzschild (U. S. A.) described results obtained from unmanned balloons at about 82,000 feet (*Sky and Telescope*, January, 1958, page 112). These balloon expeditions indicate that excellent pictures of the photosphere can be made at high altitudes, above the densest part of the earth's atmosphere, despite great technical difficulties. However, photographs made by J. Rösch (France) and others show that first-rate pictures of the solar surface can be made from well within the earth's atmosphere when seeing conditions are at their best.

The studies of the fine structure of the photosphere were supplemented by two papers on the over-all view. Dr. Dollfus reported that the white light from all points of the solar disk is polarized in the proportion of one to 10 parts in 10,000, and that the degree of polarization is constant. But on the 13th of April, 1958, he found a small area near a sunspot where there was abnormally high polarization that varied rapidly in the course of an hour. This area could not be connected with any feature on spectroheliograms or direct photographs taken at the same time. The observed polarization may have

**The author (with briefcase) and other astronomers inspect a new Zeiss telescope model on display at Moscow. Three of the group are, from left to right: V. P. Zessewitch (U. S. S. R.), Orren C. Mohler (U. S. A.), and Mrs. P. P. Recillas (Mexico). U. S. S. R. Academy of Sciences photograph.**

been caused by the solar corona; hence, a method of observing the corona over the disk of the sun may be indicated. Some observations of limb darkening during an eclipse of the sun, discussed by E. R. Dyer (U. S. A.), emphasized the importance of exact knowledge of the profile of the moon's edge.

Strangely enough, the fundamental structures – faculae and plages – received notice in only two instances. The Astronomer Royal, R. v. d. R. Woolley, asked Commission 11 for an opinion on the value of the Greenwich photoheliographic results, which are a series of careful measurements of the areas of sunspots and faculae, extending over nearly three-quarters of a century. These data attain a standard of precision not approached by other summaries, and the IAU opinion was strong that publication should be continued. The other mention of plages was in a paper by E. R. Mustel (U. S. S. R.), who considers them to be the sources of particles capable of producing terrestrial magnetic storms.

Sunspots attracted somewhat more attention, mainly as indicators of solar activity rather than for their own peculiarities. The members of the solar commissions were unable to agree on a rapid method of measuring changes in spots. Part of the difficulty arises from the small scale of the variations that occur fairly rapidly. Dr. Rösch showed some photographs of sudden changes taken on the Pic du Midi when conditions were favorable. These showed the necessity of excellent seeing for such records, as poor seeing may sometimes introduce spurious effects that often mask real variations.

To obtain spectra of integrated (white) sunlight is only slightly more difficult than to observe the sun's disk, its faculae, and sunspots. At Moscow for the first time, the discussion of observations of integrated solar spectra was divided into two parts, one dealing with work at ground observatories, the other with spectra obtained above the denser parts of the earth's atmosphere.

Concerning the former, Mrs. C. M. Sitterly (U. S. A.) reported great progress in the revision of standard solar wave lengths (the *Revised Rowland Table*) for the photographic region of the spectrum. Some sample proof sheets have been printed, and it seems the table is near publication. M. Minnaert (Holland) described the difficulties encountered in attempts to fix the level of the continuous background of the sun's spectrum. A paper by L. Goldberg (U. S. A.) dealt with a possible interpretation of the intricate structure at the core of the H and K lines of ionized calcium. The intimate but unexplained connection between these features and the absolute magnitudes of stars demands a new theory of formation of the lines.

The quality of the integrated solar spectra photographed from high altitudes is improving so fast that new identifications and measurements of wave length are being derived for nearly every new plate. While no measurements of wave length can be made with acceptable precision for the region on the short-wave side of 2800 angstroms, approximate values aid identification of the spectral lines in this region. After a line is identified, it is assigned the wave length known from laboratory studies of the element producing it. Hence the actual wave lengths of the ultraviolet lines in the atmosphere of the sun are unknown, but at present it is of greater interest to know which atoms are producing the particular lines.

M. Dubin (U. S. A.) reported that rocket ultraviolet solar spectra support the hypothesis that the Lyman-alpha line of hydrogen does not change in intensity during the sunspot cycle.

Perhaps the solar observations that require the most complicated procedures are the measurement and mapping of magnetic fields on the sun. A. B. Severny (U. S. S. R.) finds that the magnetic fields near sunspots are different before and after the outbreak of a flare. The flares tend to appear in places where the magnetic field is zero, between two regions having magnetic fields of opposite sign. But more observations are needed of changes in the fields at the times of flares. W. E. Stepanov (U. S. S. R.) has detected an alignment of small dark filaments along the lines of magnetic force. K. Y. Ohman (Sweden) suggested using the Savart plate for investigation of local fields, and with the same end in view, R. G. Giovanelli (Australia) pointed out the possibilities of the Lyot filter.

Solar flares received their usual special attention. Motion pictures of flares near the limb of the sun, presented by Dr. Giovanelli, confirm that surge prominences originate in flares. Immediately after ejection, a surge often has very low or zero contrast against the neighboring solar surface, but later changes to a dark feature at some distance from the flare itself, acquiring the name "high-speed dark flocculus" if it is observed with the solar disk as its background. Dr. Severny felt his Crimean observations indicate that very large and bright flares are composed of clusters of very small elements, analogous to the features that give rise

**W. E. Stepanov, Lvov Observatory, was one of the solar astronomers at the IAU sessions. With him here is Miss E. J. Bugoslavskaya, of the Sternberg Astronomical Institute in Moscow. From a Kodachrome by the author.**

**W. O. Roberts (left), of High Altitude Observatory in Colorado, talks shop with a Soviet astrophysicist, A. B. Severny, Simeis Observatory.**

to the spectral phenomena called "hydrogen bombs" by F. Ellerman (see October issue, page 628). These bombs may result from the motion of electrically charged atoms along the lines of force of a magnetic field. If this is the case, the stream of atoms should be constricted and might produce bombs of small size. Unfortunately, it cannot yet be established that there is a generic relation between bombs and flares.

Other interesting aspects of the flare phenomenon were reported: the difficulty of accounting for the connection between flares and the rare large outbursts of cosmic rays associated with them (J. Simpson, U. S. A.); the possibility that flare disturbances may be propagated into the solar corona (W. O. Roberts, U. S. A.); the ejection of surges that are visible in white light, from flares located very near the limb of the sun; and the rather frequent visibility of flares on the disk in white light (Dr. Ohman; K. O. Kiepenheuer, Germany).

Many flare spectrographs are now in operation, and flare spectra are being obtained in reasonable numbers, but their interpretation has encountered almost insuperable difficulties. This is due to the complex background of each spectrum, as well as to the remarkable variation in the flare spectrum from point to point.

As is well known, flares are often accompanied by increased radio emission which comes from the direction of a small area of the sun's surface near the flare. Actually, the radio emission must come from above the sun's photosphere. Flares always occur in plages, and it is now recognized that in some respects a plage may be considered as a large, low-contrast, long-lived flare. In reviewing some of the discussion at the Paris radio astronomy symposium in early August, Dr. Minnaert systematized solar radio results by showing that the bulk of the emission can be associated with plage areas. The radio waves of shortest length originate near the bottom of the chromosphere while the longest come from high in the corona, all in association with the plage, but geometrically perhaps far removed from it.

Sudden increases of radio emission, or bursts, can for the most part be correlated with plage or flare activity. On the basis of their behavior at various wave lengths, bursts may be assigned to one, or several, of five fairly well-defined categories. Additional types of variation may be needed, however, for a complete description of all radio events. R. J. Coates (U. S. A.) presented results from solar patrols at wave lengths of 20 centimeters, 10 centimeters, and 0.00006563 centimeter (hydrogen-alpha), that indicate the extremely close connections among flare disturbances at these wave lengths. Similar studies have been carried out at other wave lengths by Japanese radio astronomers.

Flares are the strongest known link between solar activity and terrestrial disturbances. In the past, sunspot numbers have been the favorite statistic when seeking correlations with events on the earth, primarily because of their method of derivation and availability. These continue to be decisive factors. E. Vassy (France) contributed a study showing that the earth's atmospheric refraction, polarization, and density change in synchronism with solar activity, as measured by sunspot numbers. Changes in the K index of terrestrial magnetic activity also show good correlation with spot numbers over the short time these indices have been available. The flare index, however, will be used increasingly in the future if a single-number value that has significance can be developed.

A. D. Fokker (Holland) reported that ionospheric effects of solar flares could be correlated strongly with a radio index of flare activity, and G. Righini (Italy)

**K. O. Kiepenheuer, director of the Fraunhofer Institute at Freiburg, is a leading German authority on the sun.**

**Since 1931, G. Righini has studied the solar spectrum with the tower telescope at Arcetri Observatory, Florence, Italy. All pictures on this page are from Kodachromes taken by the author.**

showed that a direct measurement of the brightest part of a flare was a somewhat better index for use in solar-terrestrial investigations than the purely subjective estimate of its "importance." These reports may indicate the direction to be taken in the derivation of a better flare index. F. Link (Czechoslovakia) has used aurorae as indicators of solar activity, and has correlated aurorae and fluctuations in the brightnesses of comet tails.

In attempting to interpret the details of the connections between events on the sun and on earth, N. Herlofson (Sweden) has been unable to trace the motions of particles coming from the sun. Instead, he has shown that certain essential features of these motions, which have been assumed to exist, are unlikely.

All solar-terrestrial effects are complicated by the conclusion, drawn from many kinds of observations, that the earth must be considered to be a test probe circulating within the variable structure of the sun's outermost atmosphere. English work leading to this conception of the earth's position include Dr. Blackwell's eclipse observations from aircraft, and W. R. Piggott and C. W. Allen's discussion of coronal brightness that reveals a high density of interplanetary material. S. Chapman (England) was the first to realize that if the sun's corona were to fill interplanetary space, many conflicting observations could be reconciled. Several astronomers discussed the difficult boundary value problems involved in the energy flow from the photosphere into the corona, and thence into our atmosphere.

M. S. Eigensson (U. S. S. R.) showed that correlations exist between the shape of the corona and the earth's atmospheric circulation, which is perhaps understandable if the corona envelops the earth. Problems of the heat supply for the corona and the condensation of the cool prominences from it were considered by

D. H. Menzel (U. S. A.). M. Nicolet (Belgium) calculates that the corona can supply heat to the earth's upper atmosphere at the proper rate to maintain the temperature gradient reported from artificial satellites.

Nearer the sun, the mixing of the corona and chromosphere was discussed by J. Houtgast (Holland). The motions that accompany such mixing were illustrated by moving pictures obtained at the Sacramento Peak Observatory.

The Moscow sessions in some respects offered good evidence that international meetings of this sort are becoming increasingly ineffective as a means of communication among scientists. In his acceptance of the presidency of the Union, J. Oort (Holland) expressed the view that the time had come to reconsider the purposes of the IAU, and perhaps to reorganize its entire structure so that the international aims and aspirations could be more effectively emphasized and realized in the future.

# Planetarium Operators' Symposium at Cranbrook Institute

AN INCREASINGLY important role is being played by planetariums, large and small, in the educational programs of American communities. This was amply proven at the symposium for planetarium directors and managers held at the Cranbrook Institute of Science, Bloomfield Hills, Michigan, on September 7-10, 1958.

Under the auspices of the National Science Foundation, more than 90 persons, representing 65 schools, colleges, museums, and educational institutions in 28 states, Hawaii, and the District of Columbia, took part in the four-day conference. On the first evening, they heard Dr. Donald H. Menzel, director of Harvard Observatory, deliver a public lecture on "Observatories in Space."

On the next day, Gordon S. McLintock discussed the use of a planetarium in teaching navigation, while George E. Folkman explained the use of calendars and the measurement of time. An afternoon session of six papers covered "Fitting the Demonstration to the Audience," from elementary and secondary school groups through college and adult education classes. Oiva R. Niska told how the planetarium at Ft. Belvoir, Virginia, is used in the training of U. S. Army engineers. John R. Forbes pointed out the importance of planetariums in junior museums.

Planetarium demonstrations are more effective when they are co-ordinated with local school curricula, and with museum exhibits and observatory demonstrations. This last combination was discussed by one of the earliest planetarium-observatory operators in the country, M. T. Brackbill, of Eastern Mennonite College at Harrisonburg, Virginia. Raymond J. Stein gave details of how planetariums can aid the work of local astronomy clubs, a function all too often neglected.

On the material side, much attention was paid to planetarium architecture and construction, especially the problems that arise in fitting a small installation into an existing building. Lobby exhibits and the selection of books and other matter for sale to the public were treated in an evening session on the third day. It was emphasized that after an audience has had its interest in astronomy stimulated, proper materials must be easily available to continue and encourage further study of the stars.

The closing sessions of the conference covered presentation methods, sound effects, and special-effects techniques. A recorded planetarium lecture by Richard H. Emmons was heard, and Thomas W. Voter, an artist with many years' experience at New York's Hayden Planetarium, described the use of "black light." Exhibits and dioramas that become visible only under ultraviolet illumination are becoming more widespread (*Sky and Telescope*, August, 1958, page 501). The accompanying picture of scenes from the Christmas lecture at the Stamford Museum Planetarium in 1951 is an example of what the ultraviolet-light method can accomplish.

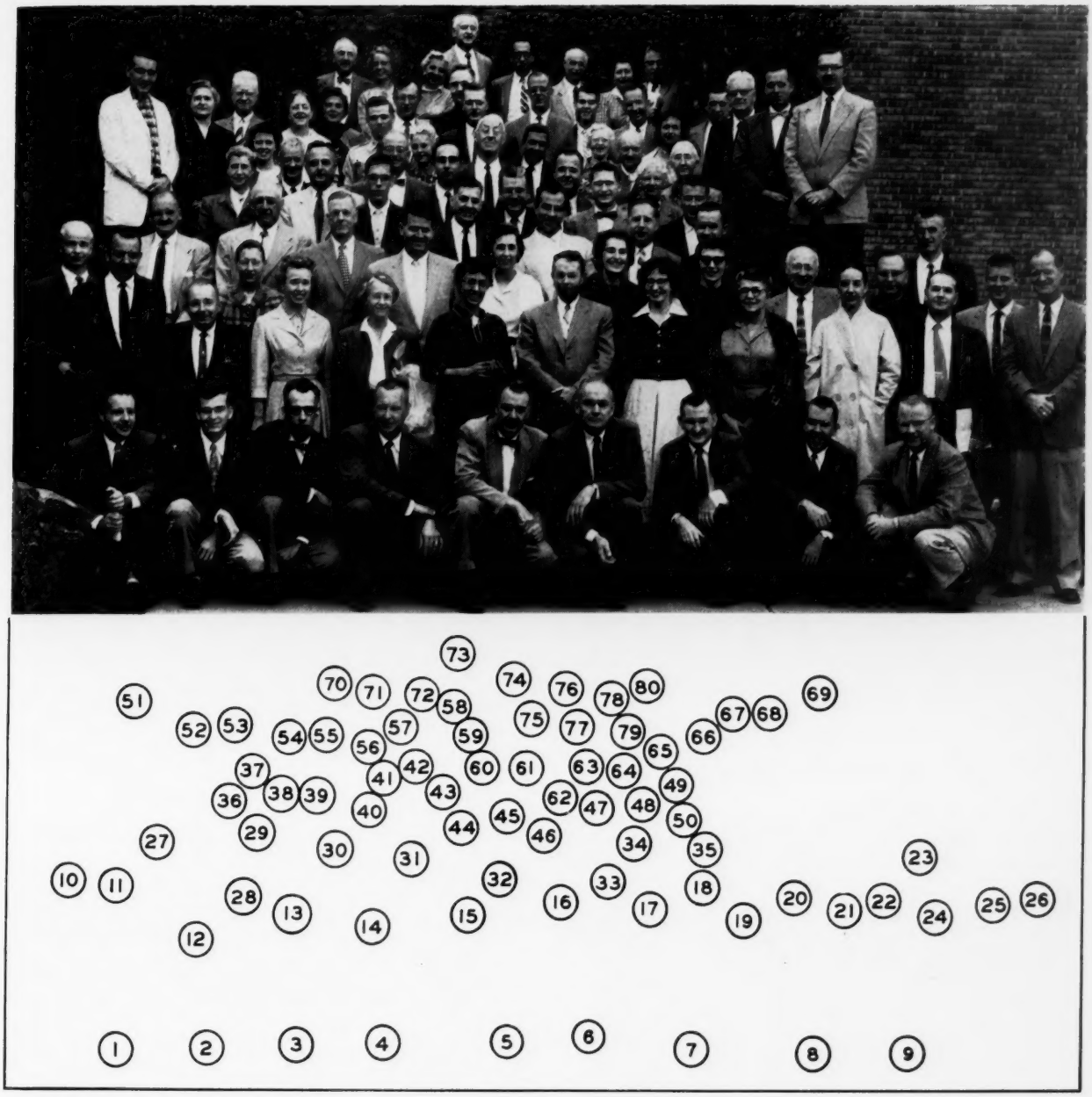
A tape recording was made of the symposium, and the proceedings are expected to be published. Information on the availability of this material may be obtained from the general chairman of the symposium, James A. Fowler, curator of education at the Cranbrook Institute.

As an outgrowth of this conference, a committee was appointed to consider establishment of an American Planetarium Society. At the conclusion of the four-day meeting, a number of delegates journeyed to Flint, Michigan, to see the new planetarium there.

**Christmas scenes in ultraviolet light, and stars from a Spitz Model A projector, at Stamford, Connecticut, in 1951. Photograph by Robert E. Cox.**

KEY TO PHOTOGRAPH

1. R. Howe, Museum, Kansas City, Mo.
2. N. Cole, Children's Museum, Ft. Worth, Tex.
3. M. Carson, Spitz Labs., Yorklyn, Del.
4. W. Frankforter, Sanford Museum, Cherokee, Iowa
5. C. Smith, State College, San Diego, Calif.
6. C. Wilder, American Museum of Atomic Energy, Oak Ridge, Tenn.
7. J. Spoehr, Spitz Labs., Yorklyn, Del.
8. H. Williams, Spitz Labs., Yorklyn, Del.
9. J. Howe, Mueller Planetarium, Lincoln, Neb.
10. R. Hatt, Cranbrook Institute, Bloomfield Hills, Mich.
11. E. Koestner, Museum of Natural History, Dayton, Ohio
12. H. Owens, County Board of Education, Adelphi, Md.
13. Mrs. R. Howe, Museum, Kansas City, Mo.
14. Elizabeth Simons, Museum, Charleston, S. C.
15. Mrs. Mae Bell, Children's Museum, Rocky Mount, N. C.
16. J. Forbes, National Foundation for Junior Museums, New York, N. Y.
17. Jacqueline Avent, Children's Museum, Nashville, Tenn.
18. Mrs. Maxine Haarstick, Public Library, Minneapolis, Minn.
19. Mrs. W. Hassler, Children's Museum, Ft. Worth, Tex.
20. W. Hassler, Children's Museum, Ft. Worth, Tex.
21. Mrs. T. Robinson, Planetarium, Dallas, Tex.
22. S. Menke, St. Ambrose College, Davenport, Iowa
23. R. Stein, Museum, Newark, N. J.
24. R. Emmons, Goodyear Aircraft Corp., Akron, Ohio
25. C. Gebler, U. S. Dept. of the Interior, Washington, D. C.
26. J. Fowler, Cranbrook Institute, Bloomfield Hills, Mich.
27. C. Starrett, Buhl Planetarium, Pittsburgh, Pa.
28. Ruth Howard, Museum, Kalamazoo, Mich.
29. L. Howland, County Board of Education, Laurel, Md.
30. H. Brown, Public Schools, Oklahoma City, Okla.



**Planetarium personnel from many parts of the United States and manufacturers' representatives met for a study conference at Bloomfield Hills, Michigan, in September. Photograph courtesy of Harvey Croze.**

31. C. Cochran, West Virginia Univ., Morgantown, W. Va.
32. Mrs. G. Smith, Goodman Planetarium, Atlanta, Ga.
33. Mrs. Devra Portoulas, Children's Museum, Brooklyn, N. Y.
34. S. Hruska, Children's Museum, Detroit, Mich.
35. R. Pfrang, U. S. Air Force Academy, Colorado Springs, Colo.
36. Margaret Noble, Public Schools, Washington, D. C.
37. Mrs. D. Moyer, Junior League, Dayton, Ohio
38. E. Stackpole, Marine Historical Ass'n., Mystic, Conn.
39. A. Praus, Museum, Kalamazoo, Mich.
40. J. Pearson, Museum, Hastings, Neb.
41. C. Brooks, Marine Historical Ass'n., Mystic, Conn.
42. Doris McMillan, Cranbrook Institute, Bloomfield Hills, Mich.
43. J. Rosemergy, High School, Ann Arbor, Mich.
44. O. Peterson, State Teachers College, Emporia, Kans.
45. M. Deusing, Museum, Milwaukee, Wisc.
46. T. Gangl, Museum of Health and Science, Dallas, Tex.
47. R. Miller, Henry Ford Community College, Dearborn, Mich.
48. Mrs. L. Kelly, Children's Nature Museum, Charlotte, N. C.
49. Mrs. M. Brackbill, Eastern Mennonite College, Harrisonburg, Va.
50. F. McGouldrick, U. S. Air Force Academy, Colorado Springs, Colo.
51. J. MacMahon, Museum of Natural History, Dayton, Ohio
52. Mrs. J. Cavanaugh, Franklin and Marshall College, Lancaster, Pa.
53. J. Cavanaugh, Franklin and Marshall College, Lancaster, Pa.
54. Jean Russell, Museum of Science, Buffalo, N. Y.
55. Mrs. J. Marsh, Museum, Fairfield, Conn.
56. J. Harnden, U. S. Army Engineer School, Ft. Belvoir, Va.
57. J. Bowen, Chicago Teachers College, Chicago, Ill.
58. C. Rice, St. Ambrose College, Davenport, Iowa
59. J. Harris, U. S. Army Engineer School, Ft. Belvoir, Va.
60. E. Linsley, Bishop Museum, Honolulu, Hawaii
61. M. Moore, Longway Planetarium, Flint, Mich.
62. W. MacBriar, Museum, Milwaukee, Wisc.
63. Heather Thorpe, Univ. of Michigan, Ann Arbor, Mich.
64. M. Brackbill, Eastern Mennonite College, Harrisonburg, Va.
65. Mrs. A. James, Junior College, St. Petersburg, Fla.
66. T. Voter, Hudson River Museum, Yonkers, N. Y.
67. H. Cornell, Milwaukee Astronomical Society, Milwaukee, Wisc.
68. F. McConnell, Fountain of Youth Properties, St. Augustine, Fla.
69. L. Roberts, Univ. of Florida, Gainesville, Fla.
70. R. Adler, Chicago Planetarium Society, Chicago, Ill.
71. Louise Davis, Children's Museum, Nashville, Tenn.
72. Martha Schaefer, Cranbrook Institute, Bloomfield Hills, Mich.
73. W. Schultz, Jr., Cranbrook Institute, Bloomfield Hills, Mich.
74. R. Levin, Chicago Planetarium Society, Chicago, Ill.
75. D. Snow, Museum of Natural History, Cleveland, Ohio
76. A. Spitz, Spitz Labs., Yorklyn, Del.
77. L. Durrance, Children's Museum, Jacksonville, Fla.
78. Mrs. R. Sullivan, Children's Museum, Charleston, W. Va.
79. J. Wells, Madison College, Harrisonburg, Va.
80. M. Degani, State Univ. Maritime College, Ft. Schuyler, N. Y.

# OBSERVING THE SATELLITES

### The Tumbling of 1958δ1

A STRIKING phenomenon of satellite 1958δ1, the last-stage rocket of Sputnik III, is the rhythmic flashing of this object as it crosses the sky. The light variations are caused by the tumbling of the rocket around an axis transverse to its length, but more information is needed for a full quantitative description of the motion.

Several other artificial satellites have likewise shown periodic variations in brightness seemingly due to rotation. Explorer I, for example, started to tumble about its axis of greatest inertia soon after launching, according to C. R. Whitney of the Smithsonian Astrophysical Observatory and C. Lundquist of the Army Ballistic Missile Agency.

Just as a spinning rifle bullet will eventually begin to wobble and turn end over end, so will an elongated orbiting body begin to precess and tumble despite its initial spin stabilization, since rotation around the long axis of such an object will not continue unchanged. Though some of the longitudinal spin may remain, part of the rotational momentum is transformed into transverse momentum.

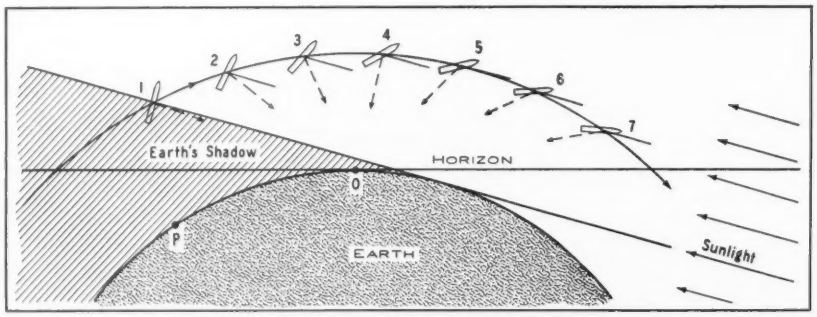
*Observing Methods.* Valuable information about the tumbling of a satellite can be derived from fairly simple observations. Consider the photograph sent by Dr. R. M. Petrie, director of the Dominion Astrophysical Observatory, which shows the variations in brightness of 1958δ1 as it passed through the constellation of Lyra. The special value of this picture is that the exposure was interrupted once each second, providing a time scale from which the period of the flashing can be accurately measured. Although a rotating shutter in front of the camera is most precise, very good results are possible if the camera lens is momentarily covered by hand in synchronization with WWV radio time signals – a practice successfully used by many Phototrack observers.

The flashing period can also be determined visually. One method is to time it directly from the WWV signals, or with a stopwatch or metronome. Another is to use a tape recorder or a chronograph to mark each moment of peak brightness with reference to WWV signals.

**The carrier rocket of Sputnik III was crossing Lyra when this photograph was taken at the Dominion Astrophysical Observatory, Royal Oak, British Columbia, on July 31, 1958. The short gaps in the trail were made at one-second intervals by a rotating shutter in front of the f/5.6 telephoto lens of the Speed Graphic camera. The first break, at the upper right, was at 10:31:25.2 UT. Each interruption was recorded by a chronograph, which also registered WWV time signals. This Dominion Astrophysical Observatory photograph is part of a systematic program by S. H. Draper, J. R. White, P. E. Argyle, and D. H. Andrews.**

In the accompanying report, James G. Moore tells of photoelectric records of Sputnik III made at China Lake, California. Such observations, while requiring more elaborate equipment, give detailed information on the amplitude of the light curve. The sample tracing shows the strongly peaked character of the maxima, a property less evident on photographic trails.

The period and direction of rotation can also be determined by monitoring the varying strength of radio emission, in the case of a satellite that has an operating radio transmitter of known antenna pattern. In all these methods – photographic, visual, photoelectric, and radio – the primary requirement is accurate timing.




**An observer at O watches an artificial satellite cross the sky, tumbling end over end. Whenever the satellite's side or principal reflecting surface makes equal angles with the directions to the sun and to O, the observer receives bright flashes. (The tumbling is assumed to be in the plane of the paper.) The diagram also shows that in general the apparent period – observed from the flashes – will differ slightly from the true period. Moreover, the amount of this difference will depend upon the direction of tumbling.**

*Interpretation.* Several observers have noticed that the flash rate changes as the satellite passes across the sky. Among them are J. B. Tatum, University of London Observatory, and A. S. Leonard, leader of the Sacramento, California, Moonwatch group. Both have deduced from this phenomenon that the rotation of the rocket case of Sputnik III is retrograde, that is, in the sense opposite to the direction of orbital revolution. (The earth's rotation, for instance, is direct.)

The different orientations of the rocket case that correspond to successive flashes seen by one observer are illustrated in the diagram. (The actual number of flashes during a passage is greater than indicated here.) Evidently the apparent period of flashing will differ from the true rotation period by an amount that depends on the relative positions of the satellite, the observer, and the sun. Moreover, the apparent period will depend on whether the rotation is direct or retrograde.

As the figure also shows, two widely separated observers (at *O* and *P*, for instance) may see the flash from the same rotation at somewhat different times, since the orientation for specular reflection toward one station may be quite different from that toward the other. To

simulate this effect, hold a mirror at arm's length and reflect a light into your left eye; the mirror must be turned to direct the light toward your other eye.

These phenomena are quite similar to those shown by the asteroid Eros, an elongated body that varies in brightness as it rotates. The apparent rotation period of Eros differs from the true period by an amount which depends on the relative positions of the sun, the earth, and the asteroid.

For artificial satellites, two forces act to oppose the rotation. One is friction with the earth's atmosphere, the other the result of eddy currents induced in the rocket shell as it rotates in the earth's magnetic field. We cannot accurately assess the relative sizes of these forces, as they depend upon the structure of the Russian rocket, which is at present unknown to us.

*Project Rotor.* So far as the writer knows, there has been no accurate determination of the instantaneous orientation of the tumble axis of 1958δ1, or of its precessional changes. If sufficiently detailed observations were made, these data could then be deduced. Progressive changes in the length of the period of tumble may also give useful information about air drag, and permit an independent evaluation of upper-atmosphere densities. Furthermore, it will be desirable to know the orientation of the satellite before its final plunge into the lower atmosphere, which is expected to occur in the rather near future.

The possibility of significant results from extensive observations of the brightness changes of 1958δ1 warrants a special observing program. Therefore, the Cambridge Research Station for Satellite Observation invites the co-operation of volunteer observers in Project Rotor. This is an organized effort to collect and analyze a large number of accurately observed times of flashes.

Since the instant of maximum reflection toward any one observer is, in general, different from that for another, comparison of the exact times of the flashes will afford a means of determining orientation of the tumble axis. The program will concentrate upon timing the first flash whose maximum occurs nine or more seconds after the start of each minute.

Many of the techniques mentioned above can be used for this purpose, according to the practice of each collaborator and the equipment he has available. The basic requirement is that flash times be accurate to better than one second; it will be necessary to have a short-wave radio receiver capable of picking up WWV time signals. A particular aim of the program is to secure observations of the same flashes from stations as widely separated geographically as possible, and therefore observations near the horizon are of special value. The latter are particularly desired for the project.

Observers and groups who are seriously interested in participating in Project Rotor should begin their observations as promptly as possible, and are invited to write to the undersigned immediately for detailed instructions, as this satellite has a very short remaining lifetime.

MARSHALL MELIN
Research Station for Satellite Observation
Harvard Observatory
Cambridge 38, Mass.

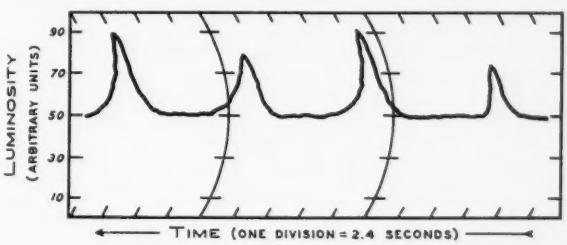
## Photometric Observations of Satellite 1958δ1

AT CHINA LAKE, California, photoelectric brightness measurements have been made of the Sputnik III rocket case. The photometer, of the type used here for airglow research, was mounted parallel to the tracking telescope of an Askania cine-theodolite, enabling the observer to keep the satellite centered in the photometer's two-square-degree field. An interference filter and a Wratten filter limited the instrument's response to a 70-angstrom band at 5467 angstroms.

As the observer tracked the satellite, an assistant monitored the output of the Esterline-Angus recorder to insure accurate tracking and to note on the record any remarks by the observer.

In this way, five twilight passages of the rocket case were observed between July 13 and October 16, 1958. On all occasions, the light curve showed primary and secondary maxima of brightness recurring at regular intervals. The average period, counted from primary maximum to primary maximum, or from secondary maximum to secondary maximum, increased steadily during the series of observations. On July 13th it was 16.6 seconds; July 24th, 17.4; August 18th and 19th, 17.8. On October 16th it was 18.4 seconds, the satellite blinking on and off every 9.2 seconds, since the secondary maxima occurred midway between the primary ones.

During the middle of June — before the photoelectric records were begun — visual observers at the China Lake Moonwatch station noted that 1958δ1 seemed to have a flashing interval of 7.5 seconds. This would correspond to a full period of 15.0 seconds. Evidently, the tumbling period of Sputnik III's rocket case increased from 15.0 seconds in mid-June to 18.4 seconds in mid-October.

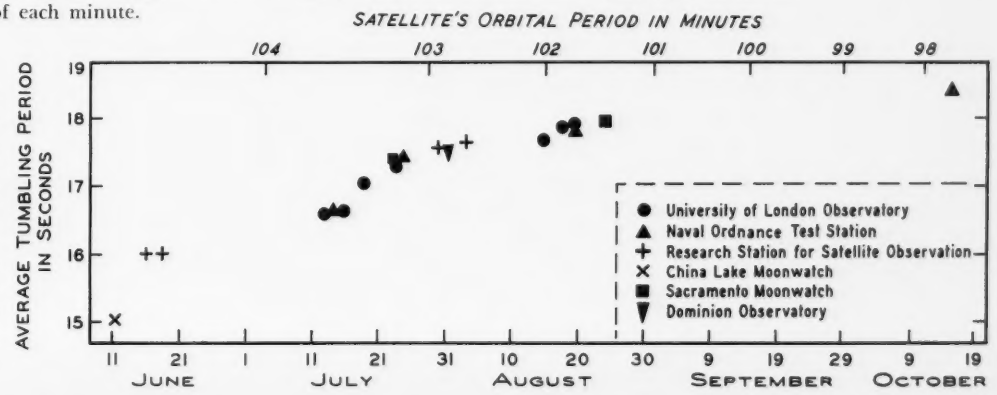



**This record of the light variation of 1958δ1 was made at China Lake, California, on August 19, 1958, at 9:05 p.m. PST. The curvature of the time scale is from the recorder pen's motion around its pivot.**

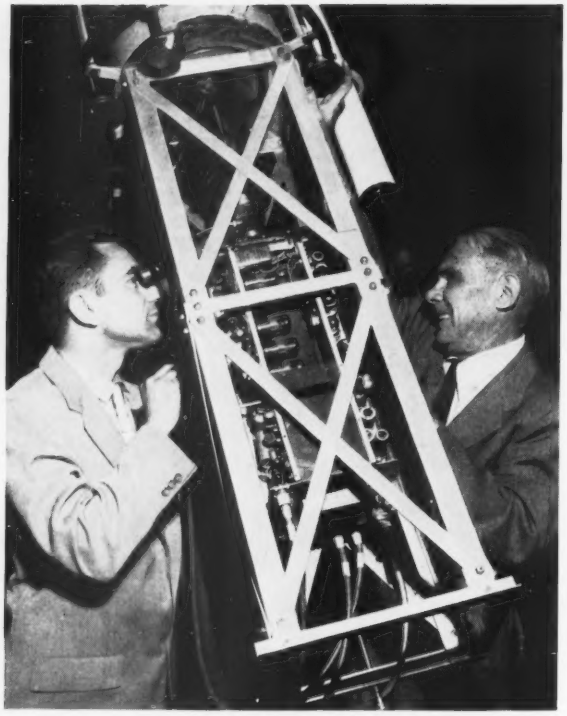
My observations were secured with the help of E. C. Bruner and E. von Huene.

JAMES G. MOORE
Atmospheric Physics Branch
Naval Ordnance Test Station
China Lake, Calif.

EDITOR'S NOTE: These results are in agreement with the observations during July and August by J. B. Tatum, of the University of London Observatory. The half-periods reported by him in *Circular* 402 of the British Astronomical Association, after doubling, are: July 12, 16.60 seconds; July 15, 16.64; July 19, 17.04; July 24, 17.38; August 14, 17.68; August 17, 17.86; and August 19, 17.90 seconds.




**The gradual lengthening of the apparent tumble period of Sputnik III's rocket case is shown for the interval June to October, 1958. This plot is based upon a diagram of James G. Moore, to which period determinations from other observers have been added.**

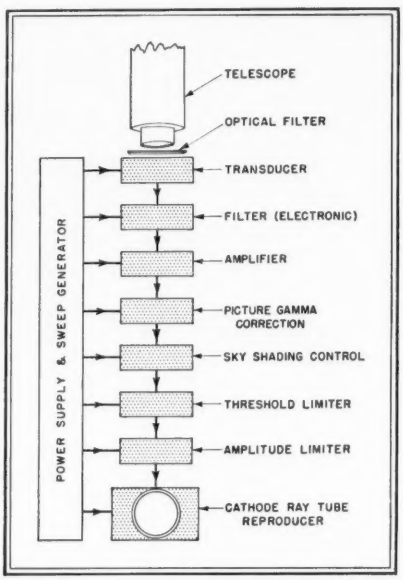


# THE CATEYE

R. K. H. GEBEL
*Wright Air Development Center, U. S. A. F.*

and LLOYD R. WYLIE
*Weaver Observatory, Wittenberg College*

**Left: The authors, Mr. Gebel at left and Professor Wylie, prepare to take a celestial photograph with the Cateye apparatus. The frame holding the transducer and other parts is attached to the 10-inch refractor of Wittenberg College.**




**The arrangement of the electronic components of the Cateye is schematically indicated in this block diagram.**

AT Wittenberg College, Springfield, Ohio, an electronic light amplifier of the Wright Air Development Center has been coupled with an f/15 10-inch refractor to obtain daytime photographs of the moon and planets. Several hundred pictures have been secured, by both day and night, over the past 18 months.

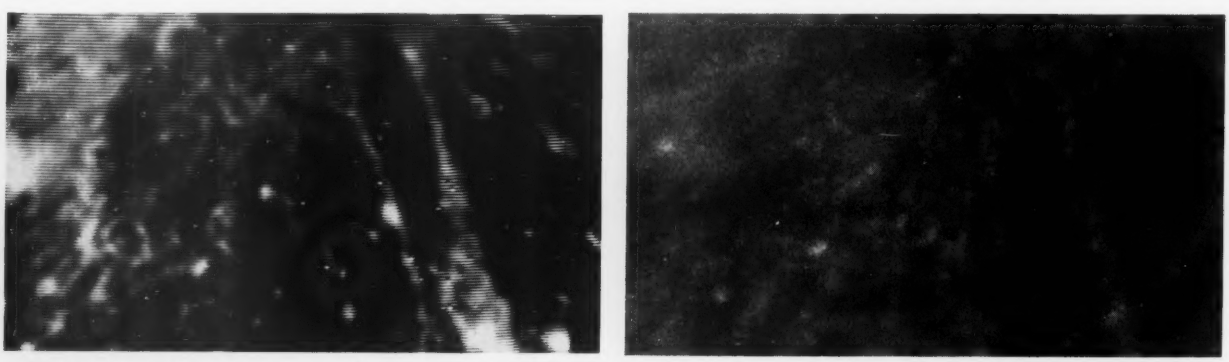
The electronic device, called the *Cateye,* is able to detect very small differences of light not apparent by conventional photography, because of its ability to increase contrast electronically. Essentially a closed-circuit television system, the Cateye has a transducer several thousand times more sensitive than conventional TV pickup tubes.

The diagram shows how we combined the light amplifier with the conventional telescope. In addition to the transducer, there is a low-noise video amplifier with associated circuits, a cathode-ray tube for reproduction of the image, and the necessary power supplies.

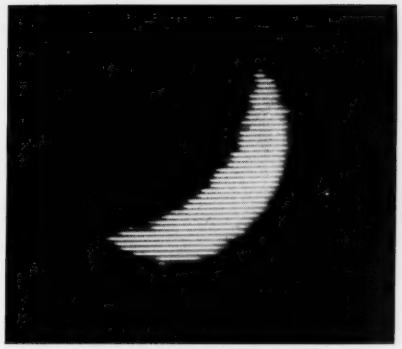
The contrast sensitivity of the Cateye permits exposures of remarkably short duration, even in the daytime. The picture of Venus was made at two o'clock in the afternoon, and the image was large because the effective focal length was 49.2 feet. Such an enlarged image is so dimmed as to require a long exposure if photographed by ordinary means. The short exposures with the Cateye thus furnish a way of reducing the blurring effects of poor seeing in the atmosphere.

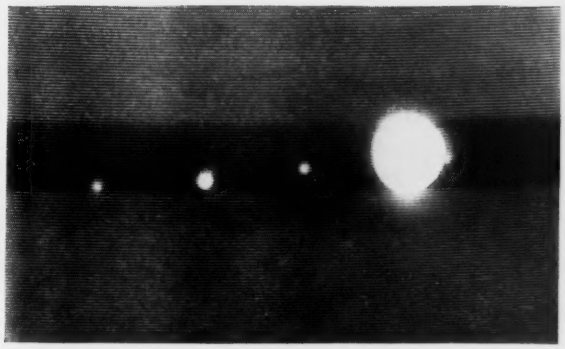
The high contrast that can be obtained with the new system also offers promise of observing structure on the moon not easily detected by visual methods. The experimental photographs of a small portion of the moon illustrate this. The one taken with the Cateye shows rays just north of Tycho as well as light and dark regions that can hardly be recognized in the other view, a direct photograph with the 10-inch refractor.

The theoretical limit for daytime detection for a matched Cateye and 10-inch telescope system is visual magnitude 10 for an exposure of only 1/30 second on a point source of light, such as a star. By



**Successive 1/25-second exposures of a small portion of the full moon near the crater Tycho, taken with the 10-inch refractor. The Cateye picture (left) shows many features of Tycho's system of bright rays that are almost invisible in the direct photograph. All pictures with this article are courtesy U. S. Air Force.**





**Two examples of photographs taken electronically with the Cateye. The crescent of Venus was recorded in daylight, with an effective focal length of 49.2 feet. The other picture shows the planet Jupiter and its four bright satellites, one at the right being very close to the planet's disk. The exposure time was 1/25 second.**

direct photography at night, the 200-inch Hale reflector can reach the 24th magnitude with a 30-minute exposure, but it is calculated that this same instrument and a Cateye should detect stars of photographic magnitude 26.5 in only 100 seconds, if the photocathode is cooled and a super-transducer is used.

The special transducers for the Cateye are being developed by the Radio Corporation of America and by Westinghouse Electric Corporation under the program of the Aeronautical Research Laboratory, Wright Air Development Center at Dayton, Ohio. The equipment is being tested at the Weaver Observatory of Wittenberg College, where Lee Devol, Heinrich Bost, Harry Beck, and Roy Hayslett are members of the observing team, in addition to the authors.

Present plans call for delivery of another Cateye to the Smithsonian Institution for use in International Geophysical Year observations.

# *ASTRONOMICAL SCRAPBOOK*

## Astronomy in Greenland

ONE of the very first astronomical observatories in North America was, surprisingly, at Godthaab, in Greenland. There during the 1780's a Danish astronomer named Linge systematically observed eclipses of Jupiter's satellites, with the aid of a primitive nonachromatic refractor eight feet long. This short-lived establishment at Godthaab was one of a series of observing stations maintained by the Danish government in its overseas possessions; there were others in Iceland and at Tranquebar, in India.

Godthaab had been founded in 1728 by Hans Egede, whose name appears on maps of the moon, marking a crater near Aristoteles. He was born in Norway in 1686, when it was a part of Denmark. Educated for the church, he was given a pension by King Frederick IV and was sent to Greenland as a missionary to the Eskimos. Landing there with his wife and four children on July 3, 1721, he built a house of stone and earth on Haabets Oe (Hope Island), but later came to Godthaab. Here he was an active missionary until he finally returned to Copenhagen in 1736.

The *Description of Greenland* that Egede published in 1757, a year before his death, contains a long and interesting account of the astronomical knowledge and myths of the Greenland Eskimos. It has special value in dating back to a time before contact with white men had made any marked changes in Eskimo culture, so we can recapture their original lore.

To the Eskimos, all the heavenly bodies were originally persons or animals who became transferred to the sky. Anningait, the moon, was a man who chased his sister Malina, the sun, into the sky. Now and then the moon returns to earth in human form to seek amorous adventure. This is why, said Egede, young Eskimo girls are afraid to stare at the moon. During solar eclipses no man goes outdoors, and during eclipses of the moon women stay at home.

As might be expected for an Arctic people who have no dark nights in summer, the Eskimos' constellation lore was limited to the stars of other seasons. To them Taurus was Kellukturset, a pack of hounds surrounding a bear; this was the star group by which they told the hours of the night. The star Aldebaran was called Nennerroak.

Another winter asterism was Siektut, the three belt stars of Orion. According to legend, these were three Greenlanders who were lost at sea while seal fishing. Egede tells us that Nelleraglek was the name for Canis Major, but this may be a slip, for few of the bright stars of this constellation rise in Godthaab's latitude, 64° north. Perhaps the star Sirius was meant, as it can attain an altitude of nine degrees above the southern horizon there.

To the Eskimos, Gemini and Auriga formed a single vast constellation, Killaub Kuttuk, the breastbone of heaven. Among the dwellers around Godthaab, Ursa Major was Tugto, the reindeer. Farther north, however, along the shores of Disko Bay, it was called Asselluit, from a wooden implement to which a seal hunter ties the end of his harpoon line.

Egede tells us about the timekeeping of the Eskimos: "They have no calendar or almanacks, nor do they compute time by weeks or years, but only by months; beginning their computation from the Sun's first rising above their horizon in winter; from whence they tell the month, to know exactly the season, in which every sort of fishes, sea animals, or birds seek the land; according to which they order their business."

To this should be added a second account, written nearly two centuries later by the Danish explorer Knud Rasmussen, who in 1903-04 visited the nomadic Eskimos living in the extreme northwest of Greenland, around latitude 77° north. A young man named Maisanguaq told him: "When the constellation of the Great Bear is seen at dawn men are filled with great delight; for then it will not be long till the light comes again.

"And when at last the Sun comes men call out: 'Joy! joy! the Great Warmer has come; soon we shall be able to seek the sunny side!' And then comes the time when people build sheltering walls of snow and gather round a man's meat at great banquets."

Curiously, this same Maisanguaq told Rasmussen the identical legend of the origin of the sun and moon that Egede had learned over 150 years before and nearly a thousand miles farther south.

JOSEPH ASHBROOK

### *SIMULATED LUNAR CRATERS*

The most recent laboratory experiments attempting to imitate the characteristic forms of the moon's craters have been made at the University of Utah's High Velocity Laboratory by William S. Partridge and Howard B. Vanfleet. They report their results in the *Astrophysical Journal* for September.

In some of their trials, they fired small aluminum and iron cylinders into a mild steel plate at speeds of 1½ to two kilometers per second. Each pellet had a small cavity bored in its leading flat face. Its impact would produce a shallow crater with a raised rim, and having a central hill with a small hole in its tip.

Although the laboratory conditions did not match those on the moon, it appears that the abundance of lunar central peaks with summit craterlets can no longer be considered a strong argument against the impact hypothesis.

# GETTING ACQUAINTED WITH ASTRONOMY

## TIME AND THE SKY — I

ALTHOUGH TIME is intuitively familiar to all of us, it defies satisfying definition. It is known to us by our sense of duration, rather than by what it actually is. When ages ago mankind first sought some way of keeping track of time, it was natural to turn to recurring astronomical phenomena, such as day and night and the seasons. These are the basis of the units of time we use today.

The sky is a huge clock. The stars and the sun move as hands across the face of the heavens in a steady and unceasing motion. Just as a glance at a man-made clock seems to show its hands stationary, a casual look at the night sky shows the starry dome apparently motionless. A few minutes' watching, however, reveals the westward motion of the stars.

It is the rotation of the earth on its axis that causes this apparent parade of astronomical objects across the heavens. We are not conscious of this rotation. The sun seems to rise, but actually our horizon is shifting downward as we move eastward with the turning earth. Similarly, the sun does not set; each evening our western horizon moves upward, hiding the sun from our view.

To the watcher of the skies at night, there is the distinct impression that he is at the center of an immense, slowly turning heavenly globe to which the stars are fixed. Starting with this useful concept of the *celestial sphere*, time and sky coordinates may be simply explained.

For any observing point on the earth's surface, the *celestial meridian* is an imaginary circle on the sky, passing through the *zenith* or overhead point and the north and south points of the horizon. We measure the flow of time by the steady apparent rotation of the celestial sphere, counting as one day the interval between two successive passages across the celestial meridian of the same celestial object. Because the sun is continually changing its position with reference to the stars, however, we must distinguish between time as indicated by the sun and that measured from the stars. Time referred to the observer's meridian is *local time*.

### SOLAR TIME

Because the sun gives light and heat and in many ways controls our daily life, timekeeping units based on its apparent motions are of greatest importance. Basically, any kind of *solar time* uses the definition that it is 12 o'clock when the sun crosses the meridian, and the day is the time interval between two such meridian transits.

But the sun's motion among the stars is not uniform, and time based on the actual sun (called *apparent solar time*) flows at a nonuniform rate. This is the kind of time indicated by a simple sundial, but it is neither practical nor desirable to build mechanical clocks that could follow the nonuniformities. Long ago, therefore, astronomers invented *mean solar time*, which is based on a fictitious mean (average) sun that by definition moves at a constant rate. For all ordinary purposes, each *mean solar day* is exactly as long as the preceding one, and it contains 86,400 seconds of mean solar time.

The difference between apparent and mean solar time is called the *equation of time*, and indicates how far the real sun is from the meridian when a mean time clock shows local noon. Thus, if the real sun is running ahead of the mean sun, it will cross the meridian before noon by the local time clock. For instance, on December 4th this year, the equation of time is +10 minutes, and at local noon the sun in the sky will already be 10 minutes past the meridian.

The equation of time never exceeds about $\pm 16\frac{1}{2}$ minutes, and its amount on every day of the year is listed in the *American Ephemeris* and other almanacs. Four times a year apparent and mean time are the same, and the equation of time is zero. This happens on about April 15th, June 14th, September 1st, and December 24th.

### STANDARD TIME

An observer one degree of longitude west of you will see the sun come to his celestial meridian four minutes later than it does for you; therefore, his local time is four minutes slower than yours. Until the 1880's, each community in the United States used clocks that showed the *local mean time*. A traveler had to keep changing his watch as he went from one place to another. The inconvenience and confusion spread with the growth of railroads and long-distance telegraph systems over the country.

For practical reasons, therefore, we have adopted a system of *standard time* in the United States, and it is part of a world-wide network based upon the same principles. Our country (excluding Alaska) is divided into four zones, and within each the civil time is everywhere the same. These are the zones of Eastern, Central, Mountain, and Pacific standard time, using the local times of the meridians 75°, 90°, 105°, and 120° of longitude west from Greenwich. Since 15 degrees of longitude are equivalent to one hour of time, EST, CST, MST, and PST are, respectively, five, six, seven, and eight hours slower than Greenwich time.

### UNIVERSAL TIME

Although standard time is convenient for civil use, it does not provide uniformity in astronomical work, such as in the predicting of an eclipse or the recording of a variable star observation. For such purposes, astronomers have agreed to use *Universal time* (UT). This is the time of the meridian of the old Royal Greenwich Observatory in England, at 0° of longitude, and is counted from 0 to 24 hours, beginning with midnight. Universal time is, therefore, the same as the standard time at Greenwich.

A few examples will show how Universal time can be converted to one's own standard time. For instance, it is clear from the foregoing that Central standard time (CST) is six hours behind UT:

Dec. 5, 8:30 UT = Dec. 5, 2:30 a.m. CST,
Dec. 5, 20:00 UT = Dec. 5, 2:00 p.m. CST,
Dec. 6, 3:00 UT = Dec. 5, 9:00 p.m. CST.

In the last case, we rewrite Dec. 6, 3:00 UT as Dec. 5, 27:00 UT to allow the subtraction of six hours, which gives Dec. 5, 21:00 CST, or 9:00 p.m.

*(To be continued)*

EDITOR'S NOTE: This series on time is prepared from material originally written by the late Paul W. Stevens and by Carl P. Richards for the Astronomical League observing manual (see page 219, March, 1958).

For an excellent 31-page article, with valuable Universal time and Canadian time-zone charts, see "Standard Time and Time Zones in Canada," by C. C. Smith and M. M. Thomson, in the October, 1958, *Journal* of the Royal Astronomical Society of Canada, 252 College St., Toronto 2B, Canada.

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## *SOME POSSIBLE EVIDENCE OF EVOLUTION IN INDIVIDUAL STARS*

*(Continued from page 76)*

could change by a greater factor than 1.86 as the star passed through the band of pulsation.

The sample of variables we have considered is small, and in no case has the period of one of these stars been followed for much more than 50 years. It is possible that future observations will show that the changes in period are not systematic and therefore not evolutionary. But it should also be recognized that all modern theories of stellar evolution indicate increases in period of the order of 0.1 second per century. Even if no small period changes had ever been observed, we would be justified in predicting them and searching for them.

Thus we cannot yet be certain that the observed changes in the periods of the Beta Canis Majoris stars are truly evolutionary in character. Nevertheless, if they are, they give us an exceedingly sensitive method of detecting evolutionary changes in individual stars. Direct measurements of a star's mass, radius, or luminosity are so crude in comparison that they offer no hope of revealing evolutionary changes within intervals of hundreds or thousands of years.

# Amateur Astronomers

## AAVSO Meets in Springfield

THE Museum of Natural History in Springfield, Massachusetts, was host to the fall meeting of the American Association of Variable Star Observers, October 10-12. Last year's gathering coincided with the successful launching of Sputnik I; at this year's session the lunar probe Pioneer was traveling out to nearly 80,000 miles from the earth.

On Friday evening, the 60 members and guests heard Newton and Margaret Mayall describe their summer trip to Scandinavia and to the IAU meeting in Moscow, a travelogue illustrated by some beautiful slides. Following this, there was a special demonstration of the Seymour Planetarium, given by the museum director, Frank Korkosz.

Saturday morning was devoted to business. The membership of the association continues to grow, standing at 600. Many active observing projects now under way were reported. During the past 12 months, 143 observers have contributed a total of 51,317 determinations of variable star magnitudes, a valuable addition to the knowledge of these objects. At the afternoon session three new officers were elected: Ralph Buckstaff, Oshkosh, Wisconsin, president; Edward Oravec, Tuckahoe, New York, first vice-president; and Dr. Dorrit Hoffleit, Maria Mitchell Observatory, second vice-president.

The rest of the afternoon was given to talks by members. Walter A. Feibelman, Pittsburgh, Pennsylvania, has observed 21 auroras since the start of the International Geophysical Year, taking over 400 pictures. He measures their brightness with a photoelectric photometer, and photographs their spectra by means of a grating spectrograph.

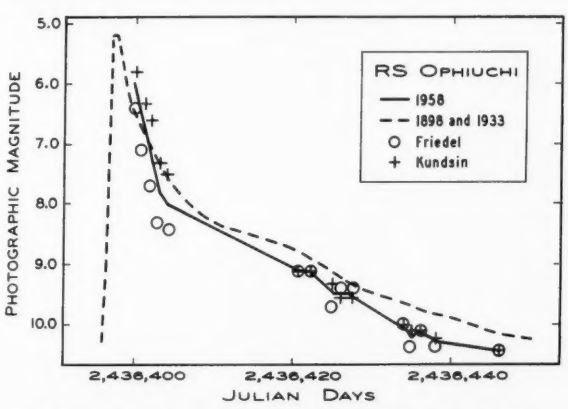
Harry L. Bondy of Flushing, New York, discussed the Solar Division's SEA program (*Sky and Telescope*, February, 1958, page 183). An SEA is a sudden enhancement of atmospherics, a surge in radio noise received at 27 kilocycles. There are six AAVSO stations in operation in this country recording the phenomenon. Ways of explaining the diurnal variations in reception of 27-kilocycle noise were presented by David Warshaw, Brooklyn, New York, and by Philip J. Del Vecchio, Paterson, New Jersey.

One of 1958's outstanding events for variable star observers was the sudden brightening in July of the recurrent nova RS Ophiuchi (page 555, September issue). Andrea R. Kundsin, Wellesley College, and Margo Friedel, Vassar College, obtained the accompanying photographic light curve for this star, while they were working at Maria Mitchell Observatory last summer. This curve matches closely those for the two previously observed outbursts, in 1898 and 1933, indicating a definite pattern for RS Ophiuchi's explosions. The visual magnitude of this nova had dropped to 10.5 by the beginning of October, according to AAVSO observations.

The final presentation was of some fine coronagraph and spectroheliograph pictures by Walter J. Semerau, Kenmore, New York (see *Sky and Telescope*, May, 1958, page 368).

Following the Saturday evening banquet, many members drove to Suffield, Connecticut, for a star party at Clinton Ford's observatory. The night was clear and crisp, and most remained until the small hours to enjoy the wonders of the heavens.

W. E. S.




**Observations by Andrea R. Kundsin and Margo Friedel at Maria Mitchell Observatory show brightness changes of RS Ophiuchi during last summer. The plotted points are from plates taken with the observatory's 7½-inch photographic refractor. The dashed curve for the years 1898 and 1933 is from "Bulletin" 912, Harvard Observatory.**

### THIS MONTH'S MEETINGS

**Austin, Tex.:** Forty Acres Astronomy Club, 8 p.m., physics building, University of Texas. December 9, Dr. Frank N. Edmonds, Jr., University of Texas, "Russian Astronomy."

**Cleveland, Ohio:** Cleveland Astronomical Society, 8 p.m., Warner and Swasey Observatory. December 5, Dr. Victor M. Blanco, Warner and Swasey Observatory, "The Moscow Meeting of the International Astronomical Union."

**Dallas, Tex.:** Texas Astronomical Society, 8 p.m., Health Museum Planetarium. December 22, astronomical film.

**Edinburg, Tex.:** Magic Valley Astronomical Society, 8 p.m., Pan American College Observatory. December 12, Mars observations with the 17-inch telescope.

**New York, N. Y.:** Amateur Astronomers Association, 8 p.m., American Museum of Natural History. December 3, Dr. Serge A. Korff, New York University, "Origin of Cosmic Rays."

**New York, N. Y.:** Junior Astronomy Club, 8 p.m., Waverly building, New York University. December 19, Edgar M. Paulton, "Investigations in the Solar System."

Also 2 p.m., main building, New York University. December 6, Arthur E. Pearlmutter, "Visual Meteor Observing."

**Philadelphia, Pa.:** Rittenhouse Astronomical Society, 8 p.m., Franklin Institute. December 12, Dr. Louis C. Green, Strawbridge Observatory, "The Crab Nebula."

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### AN AMATEUR'S EXPERIENCE WITH PUBLIC STAR PARTIES

The present close approach of Mars recalls my experience two years ago when the planet was similarly placed. I invited the public via the newspapers to view Mars through my 8-inch reflector, which

### An Amateur Astronomer's Wife

*I wake up with a start in the dead of the night,*
*I know something is wrong, and I turn on the light.*
*The place on the pillow beside me is bare,*
*My husband is missing, he's gone. Who knows where?*
*Perhaps he's recounting his variable stars,*
*Or seeing invisible markings on Mars.*
*When the moon is up high, and the earth's lights are dim,*
*Is he perched upon Plato's precipitous rim?*
*Oh, what is this thing that's come into our life?*

*There once was a time when my husband was mine,*
*Now he's way out in space where the galaxies shine,*
*And he spends all his time with his old telescope,*
*While I lie here alone, and I shiver and mope.*
*By the dawn he'll be back; as he grabs a few winks*
*He'll be dreaming of Venus, and Lepus, and Lynx.*
*And when he's awakened by coffee's sharp smell,*
*His eyelids will droop; he'll be grouchy, as well.*
*Oh, pity poor me, an astronomer's wife!*

MRS. HEDI E. LATTEY

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7 x 35 Central Focus

SPECIFICATIONS —

| | |
|---|---|
| Magnification | 7x |
| Objective aperture | 35 mm. |
| Eyepiece aperture | 24 mm. |
| Diameter of exit pupil | 5 mm. |
| Field of view at 1,000 yards | 551 feet |
| Field-of-view angle | 10.5° |
| Height | 128 mm. |
| Breadth | 195 mm. |
| Net weight | 950 grams |
| Weight of pigskin case | 400 grams |

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at the time was the only instrument in the area.

The response was tremendous. For several nights there was a line four persons wide and about half a block long waiting for a glimpse through the telescope.

For a week afterward automobiles would line up near my home waiting for me to set up the instrument. Some even appeared in a pouring rainstorm. When I carried the trash barrel out at dusk, the back yard would fill up with people. Both the bucket and telescope are painted white; they mistook the trash for the instrument!

My advice to amateurs giving public showings is to have everything under strict control. It also is a good idea to have other amateurs on hand to answer questions and help keep people from crowding the telescope.

ROBERT A. LUNDSTROM
205 18th Ave.
Sterling, Ill.

### AN AMATEUR OBSERVATORY IN CANADA

The two amateur observatories shown on page 568 of the September, 1958, issue make me wonder if conventional domes are the exception. My observatory, pictured here, has an eight-foot-diameter aluminum dome which rotates on 12 roller-skate wheels. The larger hatch slides over the back on pulley wheels, and the lower hatch is removable.

The building, including the dome, cost just under $200, and was designed for my 4-inch Unitron refractor. I had no experience in metalworking but was able to do all the necessary bending in my garage without difficulty.

**For most observing, including overhead areas, Gordon W. Smith slides the main hatch cover to the back of the dome.**

I would be pleased to supply further details, without charge, to other amateurs who may be interested in such a dome.

GORDON W. SMITH
191 Terrence Park Dr.
Ancaster, Ontario, Canada

### WATERTOWN, WISCONSIN

Eleven amateurs comprise the Rock River Astronomy Club. Interested persons should contact John P. Olesak, 500 S. Washington St., Watertown, Wisc.

### OKLAHOMA CITY, OKLAHOMA

Twenty amateurs, including four juniors, have organized the Astronomy Club of Oklahoma City. John W. Huffman, 212 W. Coe, Midwest City, Okla., will provide further information.

## QUESTIONS... FROM THE S+T MAILBAG

**Q.** If a lunar probe like Pioneer left the earth at almost 25,000 miles per hour, why would it not reach the moon's vicinity in about 10 hours, rather than the 2½ days predicted?

**A.** It must work against the earth's gravitational field, just as does a ball or other object thrown upward from the surface. The outward velocity decreases steadily, and hence the *average* speed of the probe is much less than 25,000 miles per hour.

**Q.** What temperature scale is being used when it is said that the sun's surface is at 5,750° K?

**A.** The Kelvin scale, in which 0° K is at absolute zero, −273° centigrade, and the degrees are of the same size as on the centigrade scale. Thus a reading on the Kelvin scale is 273 degrees higher than on the centigrade scale.

**Q.** What is "empty magnification"?

**A.** It is a power used on a telescope higher than the brightness of the image or the condition of the atmosphere permits. The light is spread out too much, and the ruinous effects of the atmosphere are enhanced, so that the observer sees less detail in the object than he would if a lower power were used. A practical observing rule is that even under good conditions the magnification should not exceed 50x per inch of telescope aperture.

**Q.** When will the next total eclipse of the moon be seen by observers in the United States?

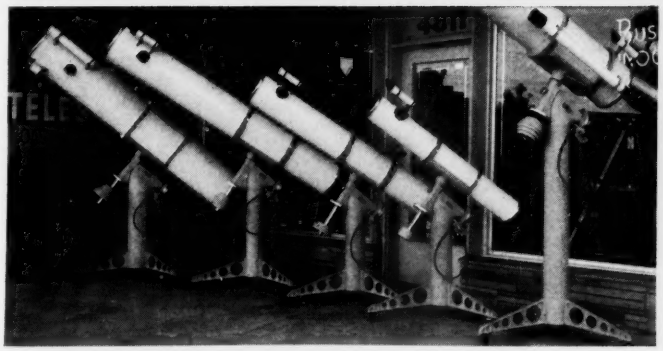
**A.** On the early morning of March 13, 1960, the moon will be totally eclipsed over all the country, with mid-eclipse at 8:30 Universal time (3:30 a.m. EST). Totality will last one hour and 36 minutes.

**Q.** How many minor planets or asteroids have been discovered to date?

**A.** There are 1,625 asteroids listed in the 1958 *Ephemerides of Minor Planets*, issued by the Leningrad Institute for Theoretical Astronomy. These are asteroids with sufficiently well-determined orbits that they may be recognized when near opposition to the sun. Several thousand more have been less well observed.

W. E. S.

# ★ ★ TRECKERSCOPE ★ ★



TRECKERSCOPES (from left to right) — 12½" DE LUXE, 10" DE LUXE, 8" DE LUXE, 6" DE LUXE, and 10" CASSEGRAIN "SKY-GIANT"

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| (Either | 10" | $195.00 | | 10" | $80.00 |
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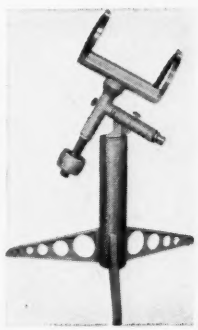

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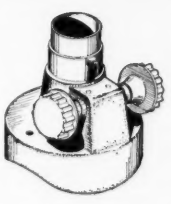

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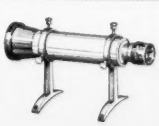

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# OBSERVER'S PAGE

**Universal time (UT) is used unless otherwise noted.**

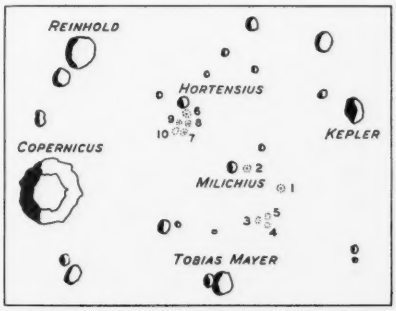
## LUNAR DOMES

BECAUSE the surface of the moon is virtually changeless, and because it has been studied by many in great detail, there is a widespread but incorrect impression that its various features are already known with complete accuracy. It is true that there are many large-scale maps and excellent photographs, but there is always something new to discover, and every now and then attention is drawn to some overlooked kind of formation.

The dark radial bands inside certain craters are a good example of this. Up to a decade ago, only a few cases were known, the most prominent being the system inside Aristarchus. Then a few papers on the subject appeared, and new radial band systems were soon being reported in great numbers. Of course, they had been there all the time, but nobody had looked closely for them.

Much the same thing happened in the case of summit craterlets. In 1949, R. B. Baldwin listed only 12 of these in his book, *The Face of the Moon*. This led me to search especially for them, and with a telescope of fair size I rapidly found another 20 or 30.

The lunar domes provide another excellent instance. Basically, a dome is a low, gentle swelling of the moon's surface. Older works say little about them, but in 1932 the veteran British observer, Robert Barker, drew general attention to one example. The object seen by Barker with his 12½-inch reflector lay inside the crater Darwin; he described it as looking like "a huge cinder-heap . . . which bristled with roughness." Darwin itself is a large, dilapidated crater fairly near the southeast limb of the moon, but nevertheless far enough from the edge to be reasonably well seen.




**Domes near the craters Hortensius and Milichius are identified in this key chart by A. Danjon. Interior dots indicate central crater pits seen by him with the 19-inch refractor of Strasbourg Observatory. Adapted from "L'Astronomie," May, 1923.**

**The characteristic appearance of a lunar dome is seen in this drawing of the crater Darwin, made by the British amateur C. F. O. Smith on January 29, 1934, shortly after lunar sunrise. About 25 miles in diameter, the Darwin dome is a low swelling traversed by two clefts. South is at the top in this view, reproduced from Vol. 32 of the "Memoirs" of the British Astronomical Association.**

The Darwin dome is quite unlike a normal mountain. Its slopes are gentle, and there is no well-defined crest. Even a 3-inch refractor will show it clearly under suitable conditions.

Although a fine specimen, the Darwin dome was not unique; smaller domes were already known near the crater Arago and inside Capuanus, for example. Still it was generally thought that domes were rarities, until after 1945. Then many other domes were described, largely through the skillful work of S. R. B. Cooke.

In the last few years, P. J. Cattermole and I have been searching systematically for domes, both visually and photographically, in order to compile a complete catalogue. Close examination of good photographs reveals many domes, but they are so low as to be generally invisible except when very near the terminator. Thus only a very small part of the moon can be searched on any one photograph, and visual work is necessary.

The first two parts of this catalogue, containing 45 domes, have already been published in the *Journal* of the International Lunar Society. Although it will take years to complete the project, some tentative conclusions are possible.

First, the domes are unexpectedly common. As a rough estimate, at least 200 may be within the range of my 12½-inch


**8-Power Elbow Telescope** (8 x 50)

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**This enlargement of part of a photograph by the 100-inch Mount Wilson Observatory reflector shows a small but distinct lunar dome one inch from the top and $2\frac{1}{8}$ inches from the left, where the great Alpine Valley opens into Mare Imbrium. The large walled plain at the lower right is Plato.**

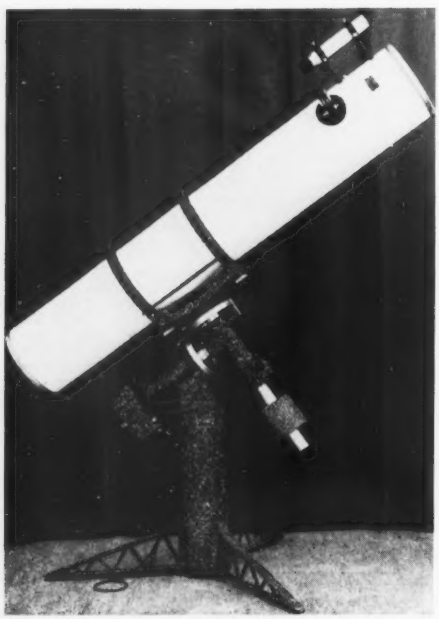
reflector. Some visual work in 1953, 1954, and 1956 with the 33-inch Meudon refractor indicates that larger aperture increases this number considerably.

Second, the distribution of domes is decidedly not random. The fact that they are more easily detected on the smooth maria than on the rougher continents may make the distribution charts incomplete. However, certain limited areas are crowded with these formations, such as the Arago region, the Prinz area in the Harbinger Mountains, and parts of Oceanus Procellarum. Inside the crater Capuanus, on the border of Palus Epidemiarum, there are eight domes visible in my telescope. On the other hand, wide areas of the moon seem completely devoid of them.

There is some evidence that domes, like the large walled formations, tend to occur in well-defined belts, one of which stretches from southern Mare Nubium across Oceanus Procellarum toward Sinus Roris. Also, domes seem to be numerous in areas where clefts are common, though there are exceptions to this general rule. These distribution relationships may have important bearing on the problem of the origin of the domes.

A fundamental question is whether or not domes are features of entirely different type from rounded hills. Unfortunately, exact measurements of their slope angles are very difficult, and the available data are inconclusive. My own studies have led me to believe that there is a real difference between a dome and an ordinary hill. On the other hand, some craters like Alpetragius, Capella, and Römer have large, rounded central summits which might well be called domes if they lay in open regions. These central elevations usually have summit craterlets, always either in the middle or, as in the case of Alpetragius, two of them symmetrically placed. Many domes have similar summit pits, equally symmetrical; better telescopes show more cases. In my opinion,


# ASTROLA Reflecting Telescopes



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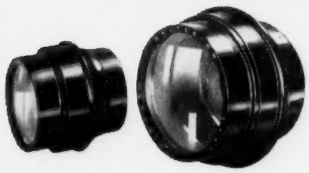

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Cat. #SU-38 **$7.95 postpaid**

**New Model Eyepiece Mount**

Same features as above but has wider base that is contoured to match the curve of a 7" to 8" diameter tube. Makes professional appearance. Furnished without Diagonal Rod #SU-9 **$9.95**

**Diagonal Rod Cat. #SU-9 ..... $1.00**

### Four-Vane Diagonal Holders

Criterion 4-vane diagonal mountings are fully adjustable, will hold elliptical diagonals in perfect alignment. Made of brass, chemically blackened. Precision adjusting screws center flat and vary its angle so that primary and secondary mirrors can be set in perfect alignment. Thin vanes with special adjustable studs.

| Cat. # | Minor-Axis Size | For Tubes | Price |
|---|---|---|---|
| S-51 | 1.25" | 6½" to 7½" | $10.00 |
| S-52 | 1.30" | 6½" to 7½" | 10.00 |
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### Finder Mount Bracket

Specially constructed exclusive design double post, solid one-piece bracket. Insures lasting adjustment because of its construction. It is easily mounted. 6 adjusting screws for collimation included. Black wrinkle finish. Two models.

Cat. # S-66 — for diameters to 1⅛" **$7.50**

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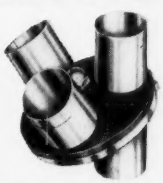
| | | | |
|---|---|---|---|
| 3" | $3.00 | 6" | $6.00 |
| 4" | 3.50 | 8" | 12.50 |
| 5" | 4.00 | 10" | 14.75 |

### Revolving Turret



The Criterion Revolving Turret holds three eyepieces so that, as desired, the powers of the telescope can be changed by merely turning the turret to a different ocular. Click stop insures positive and accurate positioning of each eyepiece. Turret holds eyepieces of standard 1¼" outside diameter. Fits into the holder of any refractor or reflector telescope that uses 1¼" eyepieces. Requires no alteration or adjustment and can be attached as easily as putting eyepiece into scope. Made of brass and aluminum with polished chrome-plated barrels.

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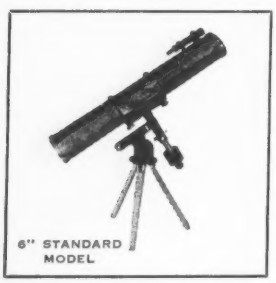

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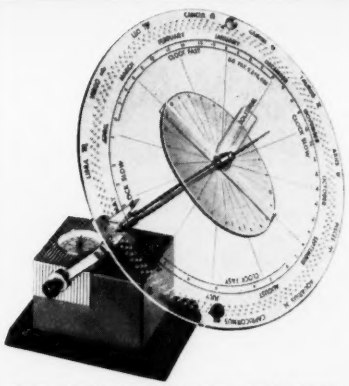

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summit pits are the rule rather than the exception.

Dr. Cooke has noted that the domes are invisible when the solar altitude is more than 10 or 15 degrees, and that under a low sun they appear darker than their surroundings, as if seamed with minute shadow-filled fissures. My observations confirm this for some domes, in particular that in Darwin. But this darkness does not seem to be a general rule, and therefore does not contradict the suggested relationship with the rounded central elevations in craters like Römer.

Domes do not seem to be the youngest of lunar formations. Some of them are cut by clefts, as may be seen in the sketch of Darwin shown on page 91. Another example is in Mare Serenitatis near Menelaus, where a small dome is completely divided by a branched cleft — a delicate object.

The amateur who would like to view some domes for himself can readily locate several in a 3- to 6-inch telescope, provided he looks when the object sought is very close to the terminator. The easiest is the large swelling in the northern part of the floor of Darwin, already mentioned. Two conspicuous domes lie in Mare Tranquillitatis, one of them north and the other east of Arago, at a distance from that crater of about two of its diameters. Both are nearly the size of Arago itself.

A somewhat smaller dome can be found in Mare Nubium, just east of the crater Kies. It is shown in a drawing by A. C. Larrieu which appeared on page 138 of the January, 1958, *Sky and Telescope*. There is a fairly conspicuous dome immediately east of the crater Milichius, while a compact group of five adjoins Hortensius to the northwest.

PATRICK MOORE
Glencathara, Worsted Lane
East Grinstead, Sussex, England

**While stationed as a satellite observer at Shiraz, Iran, Charles F. Capen, Jr., drew these pictures of Mars using Wratten filters to increase contrast differences between the planet's surface markings and atmospheric features. The arrow indicates the direction of the rotational axis of Mars. The outlines are circles swung with a drawing compass, and the terminator was marked with another circular arc, though actually it is part of an ellipse. The first picture (left) is in yellow and red light, using filters 21 and 25. For the second sketch, in green light, filter 57 was employed. The third, with filters 38 and 47, emphasizes blue light, and reveals features in the atmosphere of the planet.**

### MARS DRAWINGS USING FILTERS

The effect of observing Mars in different colors can be readily seen in the accompanying drawings, made on the morning of July 16, 1958, from 0:30 to 1:16 Universal time. The series was drawn in the sequence red, green, and blue, using a 7-inch Cassegrainian reflector. At the middle of this observing session the longitude of the Martian central meridian was 261°. On this date Mars presented a disk 9″.34 in diameter.

The Martian green and blue-green surface features appear with enhanced contrast when viewed in red and yellow light. In the first drawing note the detail in the dark triangle of Syrtis Major, and compare it with that recorded in green light (second picture). A large white area covering the region of Hellas (located above Syrtis Major) is clearly defined in the latter, indicating a surface or low-altitude atmospheric feature.

High-altitude clouds above the south polar cap and lying along the northern sunrise limb are noted in blue light, and only the darkest surface features are seen, quite ill-defined (third view).

More details on the effects of filters are given in my article on page 517 of the August, 1958, issue of *Sky and Telescope*.

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**Price for each item listed above:** 1 to 9 sheets, 10 cents each; 10 to 24 sheets, 8 cents each; 25 to 99 sheets, 6 cents each; 100 or more, 5 cents each.

From Stetson's *Manual of Laboratory Astronomy*, the following chapter is available as a separate booklet, at 50 cents each: I, Star Chart Construction.

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## AURORA OF OCTOBER 24TH

Early risers in the northeastern quarter of the United States saw a fine aurora borealis on the morning of October 24th, but because of widespread cloudiness few reports have been received.

In order of Eastern standard time of first observation, the display was seen by George W. Schramm, Johnstown, Pennsylvania, at 4:00 a.m.; Kenneth J. Delano, Baltimore, Maryland, 4:00 a.m.; Ronald Koczor, Ft. Wayne, Indiana, 4:15 a.m.; and David R. Kaiser, Eightyfour, Pennsylvania, 5:00 a.m.

Mr. Schramm watched the most beautiful northern lights he had ever seen, until daylight obliterated them. Long vertical rays of white appeared on a background of red and green. Mr. Delano reports these rays reached an altitude of nearly 40° throughout the display. For a short moment at 4:30, he saw a very brilliant flash of crimson, not much larger than the moon, near the base of a bright ray where practically no red was seen either before or afterward. The aurora reached its greatest extent at 5:15, but it was at its brightest earlier.

In Indiana, Mr. Koczor saw the peak of the display at about 4:55, with rays reaching within 10 degrees of the zenith and filling the northern sky. There were bright cherry-red patches among the rays.

## SUNSPOT NUMBERS

The following American sunspot numbers for September have been derived by Dr. Sarah J. Hill, Whitin Observatory, Wellesley College, from AAVSO Solar Division observations.

**September 1,** 227; **2,** 204; **3,** 218; **4,** 226; **5,** 229; **6,** 234; **7,** 166; **8,** 164; **9,** 167; **10,** 205; **11,** 230; **12,** 262; **13,** 271; **14,** 233; **15,** 202; **16,** 184; **17,** 214; **18,** 189; **19,** 175; **20,** 175; **21,** 158; **22,** 164; **23,** 173; **24,** 175; **25,** 192; **26,** 153; **27,** 190; **28,** 228; **29,** 180; **30,** 165. Mean for September, 198.4.

Below are observed mean relative sunspot numbers from Zurich Observatory and its stations in Locarno and Arosa.

**October 1,** 210; **2,** 217; **3,** 200; **4,** 155; **5,** 152; **6,** 132; **7,** 120; **8,** 105; **9,** 109; **10,** 117; **11,** 106; **12,** 114; **13,** 133; **14,** 136; **15,** 149; **16,** 219; **17,** 208; **18,** 235; **19,** 225; **20,** 231; **21,** 202; **22,** 242; **23,** 230; **24,** 173; **25,** 166; **26,** 158; **27,** 152; **28,** 172; **29,** 200; **30,** 187; **31,** 210. Mean for October, 173.1.

Zurich predictions for the smoothed monthly sunspot numbers are: December, 174; January, 171; February, 168; March, 165; April, 162.

Each month on the 5th the Swiss Broadcasting Corporation broadcasts the Zurich numbers to North America, at 1:35 and 4:20 Universal time (8:35 and 11:20 p.m. EST on the 4th) on wave lengths of 48.66, 31.46, and 25.28 meters. Broadcasts to South America are made on the 4th at 23:30 UT on 31.46, 25.28, and 19.59 meters, and on the 5th at 3:45 UT on 31.46 and 25.28 meters. This schedule will be followed through April 5, 1959.


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# BOOKS AND THE SKY

## STRUCTURE AND EVOLUTION OF THE STARS

**Martin Schwarzschild.** Princeton University Press, Princeton, N. J., 1958. 295 pages. $6.00.

ASTRONOMICAL literature abounds with isolated papers covering the observational and theoretical aspects of stellar evolution. Developments have been coming so rapidly during the past 10 years that it has been difficult to keep up with the latest results. The need has long existed for a book to summarize the present status and to serve as a springboard for further progress. Martin Schwarzschild has filled this gap in a highly informative and provocative manner.

There are few who will read this work from cover to cover. All astronomers will find items of interest in the first chapter, which deals with observational material. You can understand far better the problems theorists face when you realize, for example, that only one accurate determination of the mass of a giant star had been made up to the time this book was written.

Physicists will want to skim through the second chapter on the fundamental physical laws and processes, while mathematicians do not need the third, which deals with mathematical techniques. And only those active in the theory of stellar interiors will probably bother with the detailed treatment of stellar models in the next four chapters.

By whatever route you take, though, the seventh and final chapter is required reading for everyone remotely interested in the past, present, or future of our universe. Here the author collects the results and conclusions that can be drawn from the models for successive evolutionary phases, and describes the present tentative picture of stellar evolution.

Dr. Schwarzschild's Fig. 29.1, reproduced here, indicates the proposed evolutionary tracks of four stars all more massive than the sun. Here the co-ordinates are the logarithm of the ratio of the luminosity of the star to that of the sun and the logarithm of the effective temperature, in place of the usual absolute magnitude and spectral class or color. In this diagram the sun would be located at the point designated by ordinate 0 and abscissa 3.77.

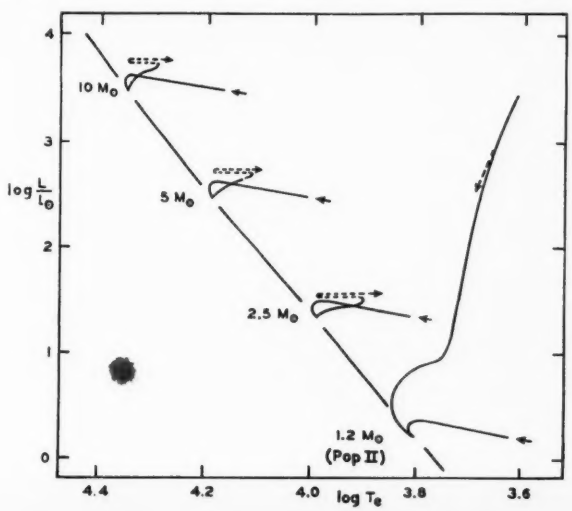
It is immediately apparent that the later stages of evolution depicted on this diagram proceed differently for a medium-weight star, 1.2 solar masses in this case, than for more massive stars, though the tracks are much the same at their beginnings.

All stars first appear in the right-hand part of the diagram at points corresponding to low surface temperatures and large radii. As contraction proceeds, each star moves in a manner indicative of a decreasing radius. When the central temperature, which is increasing because of contraction, becomes high enough to start nuclear processes, the internal structure of the star undergoes a change which causes a slight but sharp drop in its luminosity. The star now settles down in its initial main-sequence state, in which hydrogen is transformed into helium.

During the following phases, because of the large store of nuclear fuel, evolution will proceed much more slowly than during the contraction phases. The major part of a star's active life is in the states immediately following the initial contraction, if the final white dwarf stage is excluded.

Now consider a massive star. The hydrogen content of the core diminishes steadily, while that of the outer regions is unaffected by nuclear reactions. This growing inhomogeneity in the composition affects the structure of the star and causes a slight increase in the luminosity and radius, as indicated by the upward swing of the evolutionary tracks.

After the hydrogen content of the core




**On a temperature-luminosity diagram, Martin Schwarzschild has drawn the evolutionary tracks of four stars ranging in mass from 10 to 1.2 times the sun's. He considers such tracks the most powerful tools available at present for checking the theory of stellar evolution with observed data. This diagram from "Structure and Evolution of the Stars" has been redrawn for reproduction here, by permission of the publisher, Princeton University Press.**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has dropped to about one per cent, the depletion of fuel has to be compensated by an increase in the temperature, to keep the energy production in balance with the luminosity. The required temperature increase is provided by a secondary contraction of the whole star, which causes the evolutionary track to take a sudden turn to the left. This phase is soon terminated when the hydrogen content of the core is exhausted, and hydrogen burning shifts outward to a shell surrounding the now inert core.

Qualitative investigations indicate that as the hydrogen shell moves farther out in the star's interior, the helium core will increase in mass, contracting until it reaches the temperature at which helium burns. The combination of circumstances is such that a massive star will move rapidly to the right in the Hertzsprung-Russell diagram, taking up a position among the red giant stars.

The difference between the massive and less massive stars is connected with what happens when hydrogen burning starts in a shell surrounding the inert core. For massive stars the core has to contract in order that the overlying layers remain supported. However, in a star about as massive as the sun, the central density is so high that the constant temperature core can support the layers above. Thus there is no violent contraction; the beginning of helium burning is postponed to a later phase.

As the helium core grows in mass, the envelope above the hydrogen-burning shell expands. The luminosity of the star increases and it moves upward and to the right on the spectrum-luminosity diagram.

What happens after stars reach the red giant stage? To learn about this it is best to read the book, for even without advanced knowledge one can understand Dr. Schwarzschild's arguments. You should even be able to follow the general trends of his derivations since in every case he tells what he is after, why he wants it, and how he will proceed.

At the end you will have a far better understanding of one of the most exciting fields of modern astronomy. This book will be a classic in astronomical literature.

GEORGE S. MUMFORD, III
Tufts University

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## CONCEPTS OF CLASSICAL OPTICS

**John Strong.** W. H. Freeman and Co., San Francisco, Calif., 1958. 692 pages. $9.50.

DESIGNED for use in university classes for students who have studied intermediate physics and calculus, *Concepts of Classical Optics* combines the attributes of a one-author text and a collection of symposium papers by specialists in particular fields.

The reader who wishes to follow each explanation step by step should have some facility with the use of integrals, Fourier series, vectors, and complex numbers. However, those not mathematically inclined will find nearly every subject intelligibly presented and can ignore derivations and proofs without losing much of practical value. The illustrations by Roger Hayward are of great help in this connection.

The first three chapters introduce the wave nature of light, elementary diffraction theory, electromagnetic waves, and so forth. Treated next are such topics as polarization, molecular scattering, radiation pressure, phase velocity, frustrated total reflection, double refraction, and optical rotation. Six chapters deal with all types of interference, while the final ones concern images, magnification, field of view, and aberrations yielded by surfaces and optical systems.

Of the 17 appendices, the first four are on interferometry and its recent applications. With these and W. E. Williams' book, *Applications of Interferometry*, the student can obtain a rather complete coverage of the subject. (The first appendix to *Concepts of Classical Optics* is the introduction to the Williams book.)

Other topics of interest to astronomers in the appendices include interferometric spectroscopy (useful in measuring wave lengths in the far infrared), how the speed of light can be measured, radiation detectors from the human eye to the photomultiplier tube, and new developments in optical design.

The final appendix contains 108 problems, and is heartily recommended as a refresher in mathematics. The reviewer scanned this section, and then performed the first 20 exercises. He intends eventually to do the remainder of them as a challenging diversion.

Knowledge of the nature of light and the theories explaining its behavior are much more complete today than a few decades ago. Several theories are still incomplete. It is refreshing to find a writer as competent as Dr. Strong using mathematical proofs of "modest rigor" and saying, when he is explaining Fresnel diffraction with the aid of Cornu's spiral, ". . . it affords the student an example of a typical theory in physics which has an impressive neatness, inspiring awe; which makes necessary compromises, requiring prudence; and which is blemished by a lack of complete validity, requiring understanding."

The typography is excellent and the book appears to be unusually free of errors. The style is less dry than the average text, and the explanations have a lucidity and succinctness not often found together. The book should serve its designed purpose well, and certainly merits inclusion as a reference work in the advanced amateur telescope maker's library.

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# THIS IS THE WAY WE SHIP YOUR QUESTAR

In looking through a recent issue of this journal we noticed that we seem to be one of the few companies that include shipping costs to any part of the country in the published prices of its telescopes. The standard method is to ship f.o.b., letting the customer pay express or freight charges at his end. We wondered what these costs might come to, and tried to picture just what kinds of boxes or crates are used to ship conventional instruments. We then thought you might like to know how Questars reach their owners.

Questars go out by mail in this flotation package. We usually manage to ship the very same day the order is received. Entered as prepaid insured parcel post, special handling, our drum gets special treatment, traveling with the first-class-mail sacks and arriving as fast as a letter. It carries maximum postal insurance of $200, plus $800 by a standard company.

At right in the picture, the leather case holds a star-tested Questar. (Yes, each one is tested at night under actual observing conditions, just to be sure.) In the fitted case are accessories, instruction booklet, and a Bureau of Standards test chart with directions for its use.

To protect the fine British leather from abrasion during transit, we tuck it into the new gray textured-vinyl luggage cover shown. This is piped in black, has nickeled grommets and black drawstrings, and we hope it will also serve to protect the case from being scuffed when you take your Questar traveling. This completes the 12-pound inner package.

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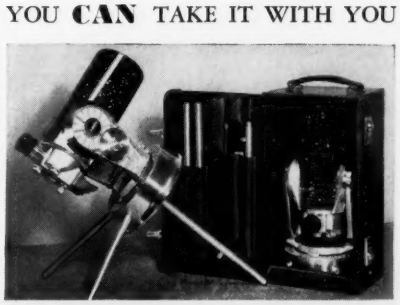


## ISAAC NEWTON'S PAPERS & LETTERS ON NATURAL PHILOSOPHY

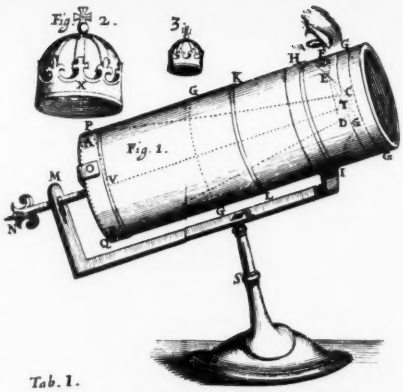
**I. Bernard Cohen,** editor. Harvard University Press, Cambridge, Mass., 1958. 501 pages. $12.50.

MORE than two centuries after his death, the complex personality of Isaac Newton holds a continuing fascination. Beside his better known roles as mathematician, astronomer, and physicist, he was a theologian of standing, an investigator of alchemy, and as warden of the mint a hardworking civil servant.

The influence Newton exerted on the physical sciences was so profound as to guide their course for many generations. In astronomy, for example, the explanation of solar system motions in terms of Newtonian gravitation was the major preoccupation until the flowering of astrophysics. Newton's ideas, as disseminated by his popularizers, did much to shape the 18th- and 19th-century European outlook on the world.

As a historian of science, I. Bernard Cohen is concerned with Newton's influence on his contemporaries. To examine this in detail, it is necessary to study Newton's writings in the form in which those contemporaries read them. Therefore Dr. Cohen has reprinted in this volume facsimiles of the writings of Newton that are no longer to be generally found in their original form. Until now, only Newton's *Principia* and his *Opticks* were thus available.

Of the more than 20 original Newton papers now reprinted, one of particular interest to readers of *Sky and Telescope* is the account, in the *Philosophical Transactions* for March 25, 1672, of a new "Catadioptrical Telescope" invented by him. It is accompanied by an engraving of the first Newtonian reflector ever built. This had a concave spherical mirror of 6⅓-inch focus, and a plano-convex eye lens giving a magnification of 38x. The primary mirror was made of an alloy of copper, arsenic, and tin, in proportions determined by many experiments.




*Tab.* 1.

**Newton's drawing of his reflector, from Dr. Cohen's book. The crown is a weathercock 300 feet away, seen with the reflector at 38 power (⅛-inch eyepiece) and with a 14x nonachromatic refractor about two feet long.**

The editor of the *Philosophical Transactions* comments on the spherical form of the primary mirror: "I believe, that M. *Newton* hath not been without considering the advantage, which a *Parabolical speculum* would have above a *Spherical* one in this construction; but that he despairs, as well as I do, of working other surfaces than spherical ones with due exactness; though else it be more easie to make a *Parabolical* than *Elliptical* or *Hyperbolical* ones, by reason of a certain propriety of the *Parabolick Conoid,* which is, that all Sections parallel to the Axis make the same Parabola."

Also of astronomical importance is Newton's description of an optical device he invented which is the direct ancestor of the modern marine sextant. However, Newton did not live to announce his "Instrument for observing the Moon's Distance from the Fixt Stars at Sea," but the record was found among Edmond Halley's posthumous papers, and was read to the Royal Society on October 28, 1742. In the meantime, the same idea had been independently discovered by Hadley in England and by Godfrey in America.

Dr. Cohen's volume also contains Richard Bentley's famous series of lectures, *A Confutation of Atheism.* Bentley wished to buttress his arguments with scientific reasons, and called on Newton to supply them. Thus Bentley's work, as well as the four letters to him from Newton, are important source material for tracing the transmission of Newton's philosophy of science. For the same reason, Bernard Fontenelle's *Elogium of Sir Isaac Newton* is also reprinted.

Many other Newton papers reproduced in facsimile here are about his optical researches, notably on refraction and color, making up nearly half of the book. Those interested in the history of astronomy will welcome this important collection of Newtoniana and the valuable notes by Dr. Cohen and his collaborators.

J. A.

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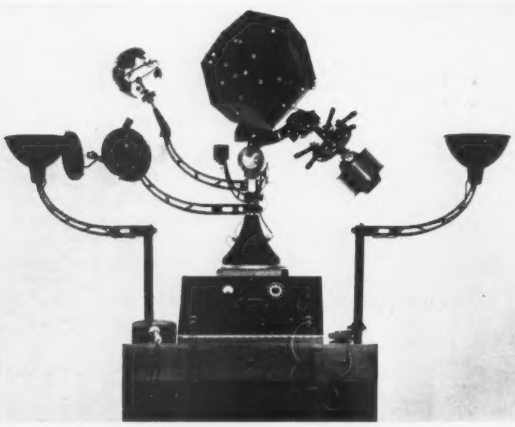

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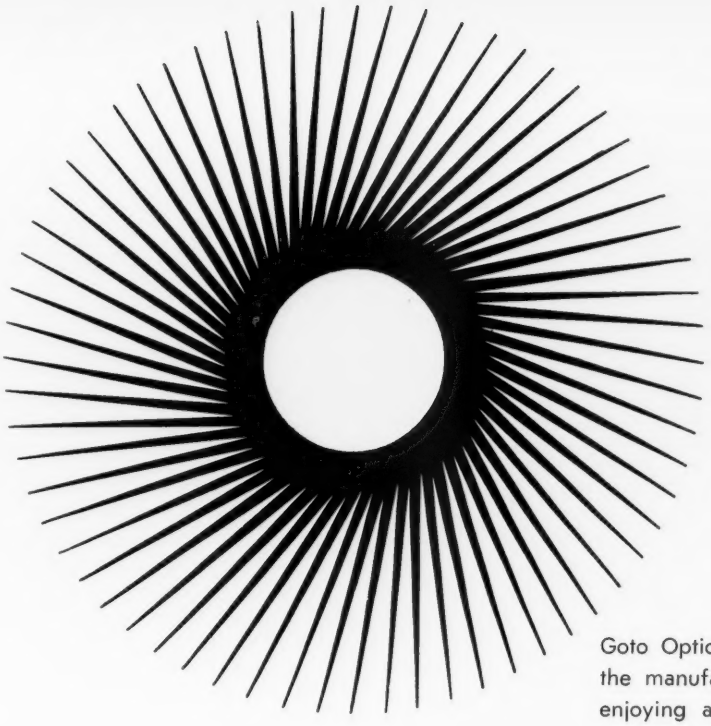

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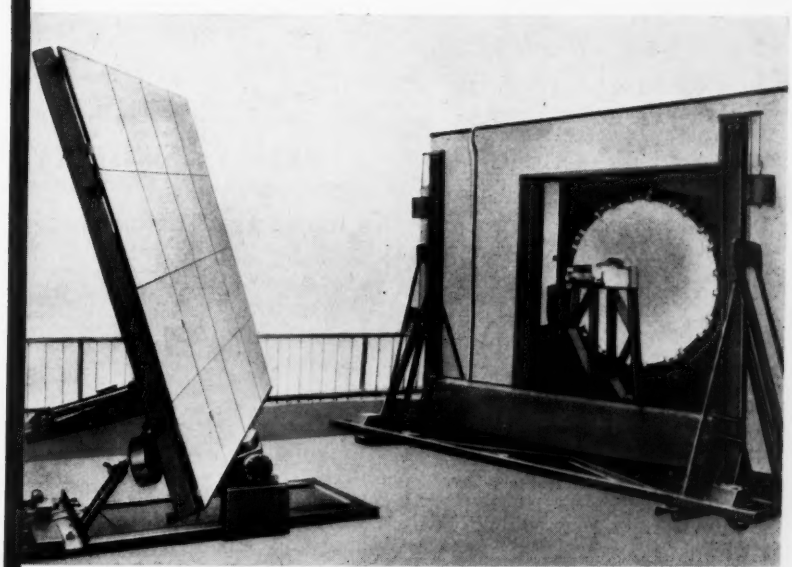
Goto Optical Mfg. Co. has for many years specialized in the manufacture of astronomical instruments and is now enjoying a world-wide reputation for the quality of its products. Besides its main line, Goto is also interested in solar energy instruments and has been carrying out research in this field. After president S. Goto attended the World Symposium on Applied Solar Energy held in Arizona, U.S.A., in 1955, Goto Optical Mfg. Co. intensified its research and testing programs.



**The picture on the right shows the Super Solar Furnace delivered by Goto to the National Industrial Laboratory in Nagoya in April, 1958. Over 3,400°C was obtained in the first test after installation of this equipment. The instrument on the left is the Heliostat with automatic driving apparatus, and that on the right is the Parabolic Mirror.**

GOTO TOKYO

*Catalogues will be sent upon request.*

**ESTABLISHED IN 1926, JAPAN'S OLDEST AND LARGEST FIRM SPECIALIZING IN ASTRONOMICAL TELESCOPES**

**GOTO OPTICAL MFG. CO.**
1-115 Shimmachi, Setagaya-ku, Tokyo, Japan

Cable Address:
GOTOPTIC TOKYO

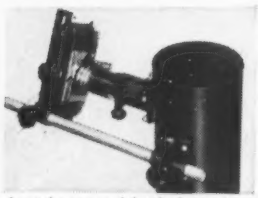
JUST REDUCED!

## SATELLITE TELESCOPE

In setting the original price of our Satellite Telescope we figured amortization of tooling and engineering over 1,000 scopes. While sales haven't reached this point, because so many made their own instruments by using our unmounted optics, we have decided to take our loss on tool amortization and reduce the price. It's still the best satellite telescope available, so get yours now! Especially made for members of MOONWATCH. Gives you the greatest possible field with the ability to observe faint objects with only slight magnification. Wide (51-mm.) diameter, low-reflection-coated objective lens. A 6-element, extremely wide field, coated Erfle eyepiece, which in combination with the objective gives 5.5 power with a big 12° field and over 7-mm. exit pupil. This scope also makes a perfect wide-field finder — a wonderful comet seeker; see complete asterisms with it.

**Stock #70,074-Y.....$39.50 ppd.**

### Take Photos of the MOON Through Your Telescope with the EDMUND CAMERA HOLDER for TELESCOPES



Bracket attaches permanently to your reflecting or refracting telescope. Removable rod with adjustable bracket holds your camera over scope's eyepiece and you're ready to take exciting pictures of the moon. You can also take terrestrial telephoto shots of distant objects. Opens up new fields of picture taking!

**SUN PROJECTION SCREEN INCLUDED**

White metal screen is easily attached to holder and placed behind eyepiece. Point scope at sun, move screen to focus . . . and you can see sunspots!

**All for the low, low price of $9.95**

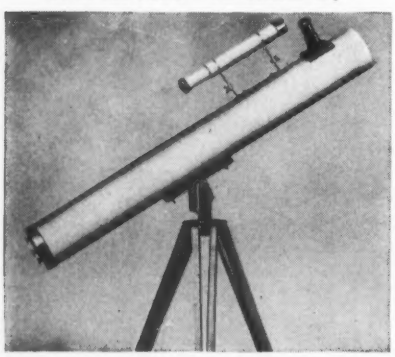
Includes brackets, 28¾" rod, projection screen, screws, and directions. Aluminum . . . brackets black crinkle painted.

**Stock #70,162-Y.....$9.95 ppd.**

Send check or money order — Money-back guarantee.

## 3" ASTRONOMICAL REFLECTOR

**60 to 160 Power — An Unusual Buy!**

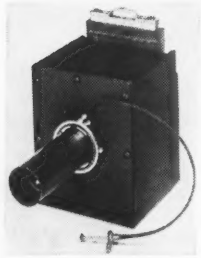


Assembled — ready to use! See Saturn's rings, the planet Mars, huge craters on the moon, star clusters, moons of Jupiter, double stars, nebulae, and galaxies! Equatorial-type mounting with locks on both axes. Aluminized and over-coated 3"-diameter f/10 primary mirror, ventilated cell. Telescope comes equipped with a 60X eyepiece and a mounted Barlow lens, giving you 60 to 160 power. A finder telescope, always so essential, included. Sturdy, hardwood, portable tripod.

Free with scope: Valuable STAR CHART and 272-page ASTRONOMY BOOK.

**Stock #85,050-Y.....$29.95 ppd.**

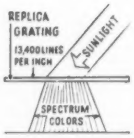
## TELESCOPE CAMERA



Here is a special camera for taking excellent closeup shots through your telescope — pictures of the moon, stars . . . terrestrial, telephoto pictures. Sturdily built, easily operated, this useful camera employs sheet film. One film holder, size 2¼" x 3¼", is included. Camera lens is 4-element — not only magnifies the image but extends it from normal eyepiece image plane to film plane. Yellow filter included. Camera box size is 3" x 4" x 5". Tube that fits into eyepiece holder is 5" long with 1¼" O.D. for standard telescopes. Cable release and 3¼"x-4½" piece of ground glass for focusing also included. Precision German-made shutter has settings for Time, Bulb, 1, ½, 1/5, 1/10, 1/25, 1/100, and 1/200 second. Also has delayed-action shutter release.

**Stock #70,166-Y.....$39.50 ppd.**

### REPLICA GRATING Low, Low Cost




It's here — after decades of effort! Replica grating — on film — at very low price. Breaks up white light into full spectrum colors. An exciting display. 13,400 lines per inch, running long way on film 8" wide — grating width 7½". Thickness about 0.005". Dispersion about 24° in 1st order. Use it for making spectroscopes, for experiments, as a fascinating novelty. First time available in such a large size — so cheaply. Comes in clear-plastic protector.

**Stock #50,202-Y....**Includes 2 pieces, 8" x 5½"—1 transmission type, 1 reflection type.....**$2.00 ppd.**

**Stock #50,180-Y....**1 piece, transmission type, 8" x 6'.....**$5.95 ppd.**

**Stock #50,203-Y....**1 piece, reflection type, 8" x 6' **$10.95 ppd.**

## Mounted Ramsden Eyepieces

**Standard 1¼" Diameter**

Our economy model, standard-size (1¼" O.D.) eyepiece. We mounted two excellent quality plano-convex lenses in black anodized aluminum barrels instead of chrome-plated brass to save you money. The clear image you get with these will surprise you. Directions for using short focal length eyepieces are included with both the ¼" and ½" models.

**Stock #30,204-Y....¼" focal length....$4.75 ppd.**

**Stock #30,203-Y....½" focal length....$4.50 ppd.**

## OBSERVE SUNSPOTS

Reduce intensity of the sun's rays, by using a Herschel wedge plus a sun filter over the eyepiece.

### UNMOUNTED HERSCHEL WEDGE

Size, 40 mm. x 55 mm.; wedge angle is 10°. The critical surface is flat to ¼ wave. Not mounted.

**Stock #30,265-Y.....$3.50**

### MOUNTED HERSCHEL WEDGE

Same size as above but mounted with diagonal holder for reflectors. Fits our rack-and-pinion holder, Stock No. 50,077-Y, that is also used on our 4½" and 6" reflectors. Holder rod is long enough for 4¼", 6", and 8" mirrors. Rod is 5/32" diameter and 5" long.

**Stock #30,266-Y....$5.50**

### INVITATION

**VISIT OUR RETAIL STORE** — (10 miles from Philadelphia — two miles from Exit #3 of the New Jersey Turnpike). When you're near us, stop in and see our big display. Our store contains many miscellaneous items at bargain prices.

## K-24 AERIAL CAMERA

War surplus — guaranteed perfect working order. Excellent camera for photographing satellites. Complete with 7" f/2.5 Kodak Aero Ektar lens and magazine which takes film 5½" wide x 26' long.

**Stock #85,067-Y.....$99.50 f.o.b. Utah**

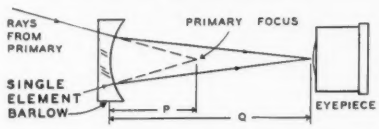
### AERIAL CAMERA LENS

**f/2.5 with 7" Focal Length**

An excellent lens — can be adapted for use on 35-mm. and Speed Graphic cameras as a telephoto lens. Three of the first four pictures of Sputnik III were taken by a student with a homemade camera using one of these lenses. Adjustable diaphragm, f/16 to f/2.5. Gov't. cost over $400. War surplus.

**Stock #70,161-Y.....$39.95 ppd.**

### DOUBLE AND TRIPLE YOUR TELESCOPE'S POWER WITH A BARLOW LENS




WHAT IS A BARLOW? A Barlow lens is a negative lens used to increase the power of a telescope without resorting to short focal length eyepieces, and without the need for long, cumbersome telescope tubes. Referring to the diagram above, a Barlow is placed the distance P inside the primary focus of the mirror or objective. The Barlow diverges the beam to a distance Q. This focus is observed with the eyepiece in the usual manner. Thus, a Barlow may be mounted in the same tube that holds the eyepiece, making it very easy to achieve the extra power. The new power of the telescope is not, as you might suppose, due to the extra focal length given the objective by the difference between P and Q. It is defined as the original power of the telescope times the quotient of P divided into Q.

**Beautiful chrome mount.** We now have our Barlow lens mounted in chrome-plated brass tubing with special spacer rings that enable you to vary easily the power by sliding split rings out one end and placing them in other end. Comes to you ready to use. Just slide our mounted lens into your 1¼" I.D. tubing, then slide your 1¼" O.D. eyepieces into our chrome-plated tubing. Two pieces provided, one for regular focal length eyepieces and one for short focal length ones.

Remember, in addition to doubling and tripling your power, a Barlow lens increases your eye relief and makes using a short focal length eyepiece easier.

Don't fail to try one of these. Many people do not realize the many advantages of a Barlow and the much greater use they can get from their telescopes. Our Barlow has a focal length of −1-5/16". We have received many complimentary letters about this lens. So sure are we that you will like it that we sell it under a 30-day guarantee of satisfaction or your full purchase price returned — no questions asked. You can't lose, so order today.

**Stock #30,200-Y Mounted Barlow lens.....$8.00 ppd.**

### WAR-SURPLUS TELESCOPE EYEPIECE

Mounted Kellner Eyepiece, Type 3. 2 achromats, focal length 28 mm., eye relief 22 mm. An extension added, O.D. 1¼", standard for most types of telescopes. Gov't. cost $26.50.

**Stock #5223-Y.....$7.95 ppd.**

# EDMUND SCIENTIFIC CO.

# Sale! Terrific Bargains!

# WAR-SURPLUS AERIAL CAMERA LENSES

## 24" Focal Length, f/6, in 23"-long Lens Cone

## Made by Bausch & Lomb and Eastman Kodak

## $39.50, Used; $59.50, New; Gov't. Cost $1,218.00

Mounted in beautiful brass cells, lenses are 4"-diameter precision 4-element type. Aero Tessar and Aero Ektar (no choice). Housed in cone — focal plane 10" beyond cone and permits attaching a film holder, eyepiece, or the like. Lenses are easily removed for other uses. Diaphragm is included — adjusts by flexible rod (easily extended) from f/6 to f/22; opens approximately 1" to 3½". Weight of lens and cone 25 lbs. Sturdy carrying trunk weighs 26 lbs.

**USES:** 1. For use as long-range, Big Bertha telephoto lens. 2. For richest field (wide field, low power) telescope. 3. As opaque projector lens. 4. For use in operation PHOTO-TRACK (photographing artificial satellites).

**SALE AERIAL CAMERA LENSES**

**Lens Cones with f/6 24" focal length —**

**Stock #85,059-Y....24", Used.....$39.50** f.o.b. Utah

**Stock #85,060-Y....24", New.....$59.50** f.o.b. Utah

**ALSO AVAILABLE**

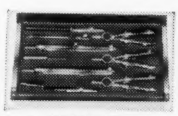
**Lens Cones with f/8 40" focal length —**

**Stock #85,061-Y.....Used.....$68.50** f.o.b. Utah

**Stock #85,062-Y.....New.....$89.50** f.o.b. Utah

## CLOSE OUT! MECHANICAL DRAWING SET

**Regular Price, $18.00 — Our Price, Only $6.00 ppd.**

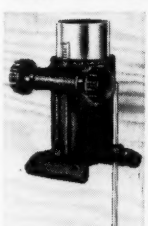


American manufacturer couldn't compete with foreign imports — thus you get a terrific bargain, even far below import prices. 10 handsome pieces in velvet-lined case. Nickel-plated brass, precision American made. Set contains 5½" Swedish ruling pen, 5½" compass, lengthening bar, interchangeable pen, dividers, 3 center-wheel bow instruments, and so forth. We guarantee you'll be satisfied or your money refunded.

**Stock #50,200-Y.....$6.00 ppd.**

**Quantity prices: 5 sets for $5.50 each ppd.**
**10 sets for $5.00 each ppd.**

## Rack & Pinion Eyepiece Mounts



Real rack-and-pinion focusing with variable tension adjustment: tube accommodates standard 1¼" eyepieces and accessory equipment; lightweight aluminum body casting (not cast iron); focusing tube and rack of chrome-plated brass; body finished in black wrinkle paint. No. 50,077-Y is for reflecting telescopes, has focus travel of over 2", and is made to fit any diameter or type tubing by attaching through small holes in the base. Nos. 50,103-Y and 50,108-Y are for refractors and have focus travel of over 4". Will fit our 2⅞" I.D. and our 3⅞" I.D. aluminum tubes respectively.

**For Reflectors**

**Stock #50,077-Y (less diagonal holder) $8.50 ppd.**
**Stock #60,049-Y (diagonal holder only) 1.00 ppd.**
**Stock #50,103-Y (for 2⅞" I.D. tubing) 12.95 ppd.**
**Stock #50,108-Y (for 3⅞" I.D. tubing) 13.95 ppd.**

## 5" DIAM. TELESCOPE OBJECTIVE AIR-SPACED ACHROMAT

Coated 4 surfaces. Focal length 71", f/14.2. Effective aperture f/15, 4.73".

**Stock #70,163-Y...Unmounted.....$125.00 ppd.**

**Stock #70,164-Y...Mounted in cell (Inside diam. 5"; outside diam. 5½" with 6½" flange) with adapter to fit 6⅞" I.D. tubing.....$150.00 ppd.**

## "MAKE-YOUR-OWN" 4¼" MIRROR KIT

The same fine mirror as used in our telescopes, polished and aluminized, lenses for eyepieces, and diagonal. No metal parts.

**Stock #50,074-Y.....$16.25 ppd.**

## STANDARD 1¼" EYEPIECE HOLDER

Here is an economical plastic slide-focus eyepiece holder for 1¼" O.D. eyepieces. Unit includes 3"-long chrome-plated tube into which your eyepiece fits for focusing. Diagonal holder in illustration is extra and is not included.

**Stock #60,067-Y.....$2.50 ppd.**

## PRISM STAR DIAGONAL

For comfortable viewing of the stars near the zenith or high overhead with refracting telescopes using standard size (1¼" O.D.) eyepieces, or you can make an adapter for substandard refractors. Contains an excellent quality aluminized right-angle prism. Tubes are satin chrome-plated brass. Body is black wrinkle cast aluminum. Optical path of the system is about 3½".

**Stock #70,077-Y.....$12.00 ppd.**

## "TIME IN ASTRONOMY" BOOKLET

By Sam Brown. All about various kinds of time, contains sidereal timetable. How to use single- and double-index setting circles, how to adjust an equatorial mount, list of sky objects. Also includes 7" paper setting circles and stripes suitable for cutting out and mounting on plywood. Wonderfully illustrated.

**Stock #9054-Y.....60c ppd.**

**OTHER USEFUL BOOKLETS**

**"OBSERVING THE SUN"**
**Stock #9056-Y.....15c ppd.**

**"TELESCOPE FINDERS"**
**Stock #9051-Y.....15c ppd.**

## Sale! GIANT ERFLE EYEPIECE

Here is an exciting bargain. We just bought a large lot of these eyepieces reasonably — so down goes the price to $9.95 for a real sale. Lens system contains 3 coated achromats over 2" in diameter. Gov't. cost over $100.00. Brand new, weight 2 pounds. The value will double when this sale is over, and triple and quadruple as years pass. If we didn't owe the bank so much money, we'd be tempted to hold onto these eyepieces. Their wide apparent field is 65°. The focal length is 1½". Lenses are in a metal cell with spiral threads; focusing adapter with 32 threads per inch is included; diameter is 2-11/16". If you don't order now and you miss out on a hundred-dollar eyepiece for only $9.95, you can't say that we didn't try to impress you with its value. You can make some super-duper finders with these eyepieces. They are also ideal for rich-field telescopes, which are becoming more popular daily, particularly in the Sputnik age. Everyone with a large reflecting telescope should have one of these.

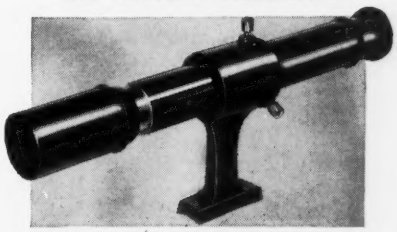
**Stock #50,178-Y.....Sale Price $9.95 ppd.**

## 3X ELBOW TELESCOPE

Sometimes the war-surplus end of this business is heartbreaking. Here is an excellent little telescope that cost Uncle Sam about $200.00. Makes a dandy finder with a 13° field. Weight 2 pounds, size 5¾" x 4½". Although our price has been only $7.50 postpaid, they just sit on our shelves year after year. Then to get an item we really wanted, we had to buy 200 more of these telescopes recently. Objective lens is an achromat, diameter 26 mm., focal length 104 mm. Amici roof prism with faces of 18 mm. x 20 mm. cost from $12.00 to $36.00 to make. Symmetrical eyepiece of 1¼" (32.5 mm.) effective focal length consists of 2 achromats with diameters of 34 mm. and focal lengths of 65 mm. At our new price we cannot afford to have our instrument man take these apart and clean them — so we told him to look them over to make sure everything is okay, and now you can buy them for only $5.00 each delivered to you.

**Stock #50,179-Y.....$5.00 ppd.**

## 6X FINDER TELESCOPE



Has crosshairs for exact locating. You focus by sliding objective mount in and out. Base fits any diameter tube — an important advantage. Has 3 centering screws for aligning with main telescope. 20-mm.-diameter objective. Weighs less than ½ pound.

**Stock #50,121-Y.....$8.00 ppd.**

## MIRROR STAR DIAGONAL

For comfortably viewing astronomical objects with refracting telescopes — also excellent with finders on reflecting telescopes. Can be used on standard microscopes as it is correct size. Eyepiece end takes oculars with 0.917" O.D. and objective end fits into tubes with 0.917" I.D. Made of fine plastic, and contains a first-surface mirror.

**Stock #30,278-Y.....$3.00 ppd.**

## 7X FINDER TELESCOPE—ACHROMATIC

**Stock #50,080-Y Finder alone, less ring mounts...$9.95**

**Stock #50,075-Y Ring mounts per pair.....$3.95**

**BE SURE TO GET FREE CATALOG "Y"**

Fantastic variety — never before have so many lenses, prisms, optical instruments, and components been offered from one source. Positively the greatest assembly of bargains in all America. Imported! War Surplus! Hundreds of other hard-to-get optical items. Write for Free Catalog "Y."

**ORDER BY STOCK NUMBER . . . SEND CHECK OR MONEY ORDER . . . SATISFACTION GUARANTEED!**

# BARRINGTON • NEW JERSEY

# AIRSPACED OBJECTIVES

## MOUNTED IN ALUMINUM CELLS f/15

We offer the lowest priced, hand-corrected, precision, American-made astronomical objective, *mounted in a black-anodized aluminum cell.* Our reputation has been established over the years as the most reliable source of high quality astronomical lenses.

**"Those in the know" BUY FROM US BECAUSE:**

Each lens is thoroughly tested by us and is guaranteed to resolve two seconds of arc or better. They are corrected for the C and F lines (secondary chromatic aberration). The zonal spherical aberration and the chromatic variation of spherical aberration are negligible. The cell is machined to close tolerances so that it will fit directly over our standard aluminum tubing, eliminating any mounting problems.

3¼" diam., 48" F.L. (uncoated) ..**$28.00** 4⅛" diam., 62" F.L. (uncoated) ..**$60.00**

Same as above with coating .....**$32.00** Same as above with coating .....**$69.00**

We can supply ALUMINUM TUBING for the lenses above.

## "BIG" ACHROMATIC TELESCOPE OBJECTIVES

We have the largest selection of diameters and focal lengths in the United States available for immediate delivery. These are perfect magnesium-fluoride coated and cemented Gov't. surplus lenses made of finest crown and flint optical glass. Not mounted. Fully corrected. Tremendous resolving power. They can readily be used with eyepieces of only ¼" focal length, thereby producing high powers. Guaranteed well suited for astronomical telescopes, spotting scopes, and other instruments. Gov't. cost up to $100.

| Diameter | Focal Length | Each | Diameter | Focal Length | Each |
|---|---|---|---|---|---|
| 54 mm. (2⅛") | 254 mm. (10") | $12.50 | 83 mm. (3¼") | 660 mm. (26") | $28.00 |
| 54 mm. (2⅛") | 300 mm. (11.8") | 12.50 | 83 mm. (3¼") | 711 mm. (28") | 28.00 |
| 54 mm. (2⅛") | 330 mm. (13") | 12.50 | 83 mm. (3¼") | 762 mm. (30") | 28.00 |
| 54 mm. (2⅛") | 390 mm. (15.4") | 9.75 | 83 mm. (3¼") | 876 mm. (34½") | 28.00 |
| 54 mm. (2⅛") | 508 mm. (20") | 12.50 | 83 mm. (3¼") | 1016 mm. (40") | 30.00 |
| 54 mm. (2⅛") | 600 mm. (23½") | 12.50 | 102 mm. (4") | 876 mm. (34½") | 60.00 |
| 54 mm. (2⅛") | 762 mm. (30") | 12.50 | 108 mm. (4¼") | 914 mm. (36") | 60.00 |
| 54 mm. (2⅛") | 1016 mm. (40") | 12.50 | 110 mm. (4⅜")* | 1069 mm. (42-1/16") | 60.00 |
| 54 mm. (2⅛") | 1270 mm. (50") | 12.50 | 110 mm. (4⅜") | 1069 mm. (42-1/16") | 67.00 |
| 78 mm. (3-1/16") | 381 mm. (15") | 21.00 | 128 mm. (5-1/16")* | 628 mm. (24¾") | 75.00 |
| 80 mm. (3⅛") | 495 mm. (19½") | 28.00 | 128 mm. (5-1/16") | 628 mm. (24¾") | 85.00 |
| 81 mm. (3-3/16") | 622 mm. (24½") | 22.50 | *Not coated | | |

● We can supply ALUMINUM TUBING AND CELLS for the lenses above. ●

## COATED BINOCULARS

American Type

"Zeiss" Type

Beautiful imported binoculars, precision made, at a low, low price. Above we have pictured the two most popular types. The American Type offers a superior one-piece frame and a clean design, pleasing to the eye. Complete with carrying case and straps. **Price plus 10% Federal tax.**

| Size | Field at 1,000 yards | Type | Center Focus | Ind. Focus |
|---|---|---|---|---|
| 6 x 15 | 360 ft. | Opera | — | $12.75 |
| 6 x 30 | 395 | Zeiss | $18.75 | 16.75 |
| 7 x 35 | 341 | Zeiss | 20.75 | 17.95 |
| 7 x 35 | 341 | American | 23.50 | — |
| 7 x 35 | 578 | American Wide Angle 11° | 35.00 | — |
| 7 x 50 | 372 | Zeiss | 24.95 | 22.50 |
| 7 x 50 | 372 | American | 32.50 | — |
| 8 x 30 | 393 | Zeiss | 21.00 | 18.25 |
| 10 x 50 | 275 | Zeiss | 28.75 | 26.75 |
| 20 x 50 | 183 | Zeiss | 33.75 | 31.75 |

## MONOCULARS

Brand new, coated optics, complete with pigskin case and neck straps.

| | Price | | Price |
|---|---|---|---|
| 6 x 30 | $10.00 | 7 x 50 | $14.75 |
| 8 x 30 | 11.25 | 16 x 50 | 17.50 |
| 7 x 35 | 12.50 | 20 x 50 | 20.00 |

**"MILLIONS" of Lenses, etc. Free Catalogue**

We pay the POSTAGE — C.O.D.'s you pay postage. Satisfaction guaranteed or money refunded if merchandise returned within 30 days.

## NEW! 6" LENSES

Our 6" objective will not need high-pressure salesmanship. Its sparkling performance speaks for itself. Test one, or have any qualified person test it; we are certain that you will be satisfied. If not, take advantage of our money-back guarantee.

### 6" DIAM. AIR-SPACED TELESCOPE OBJECTIVE

**Hard coated on 4 surfaces**

f/10 - 60" focal length { MOUNTED .....$175.00 / UNMOUNTED .. 150.00

f/15 - 90" focal length { MOUNTED ..... 175.00 / UNMOUNTED .. 150.00

We can supply ALUMINUM TUBING for the lenses above.

## "GIANT" WIDE-ANGLE EYEPIECES

**ERFLE EYEPIECE** (65° field) contains 3 coated achromats. 1½" E.F.L., clear aperture 2⅛". Has a focusing mount with diopter scale. Will make an excellent 35-mm. Kodachrome Viewer. Magnifies seven times ..... **$12.50 ppd.**

Same as above without diopter scale ..... **$9.95**

**WIDE-ANGLE ERFLE** (68° field) **EYEPIECE.** Brand new; coated 1¼" E.F.L. Focusing mount. 3 perfect achromats. 1-13/16" aperture .... **$13.50**

**WIDE-ANGLE ERFLE** 1½" E.F.L. Brand new; contains Eastman Kodak's rare-earth glasses; aperture 2"; focusing mounts; 65° field ..... **$12.50**

**1¼" Diam. Adapter** for Erfle eyepieces ..... **$3.95**

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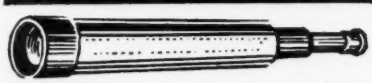

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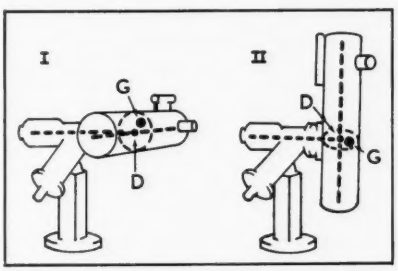
## Balancing a German Equatorial Mounting

ALTHOUGH a telescope tube may be carefully designed to achieve balance around the optical and declination axes, as discussed last month, further balancing procedures are necessary to insure smooth operation wherever the telescope is pointed to the sky. It must be in perfect balance around both the declination and polar axes, and provision must be made for adjusting the balance when minor accessories are added.

Imperfect balance may not show up when a new telescope is first tried out, but after some observing it may be noticed that in certain parts of the sky the clock drive or the slow motions work erratically, or that when the tube is pointed toward the zenith it will not remain in that position. The procedures to be followed have been analyzed by Dr. G. Van Biesbroeck, of Yerkes and McDonald Observatories, for any type of mounting, including the popular German type, such as the model in the pictures. He writes:

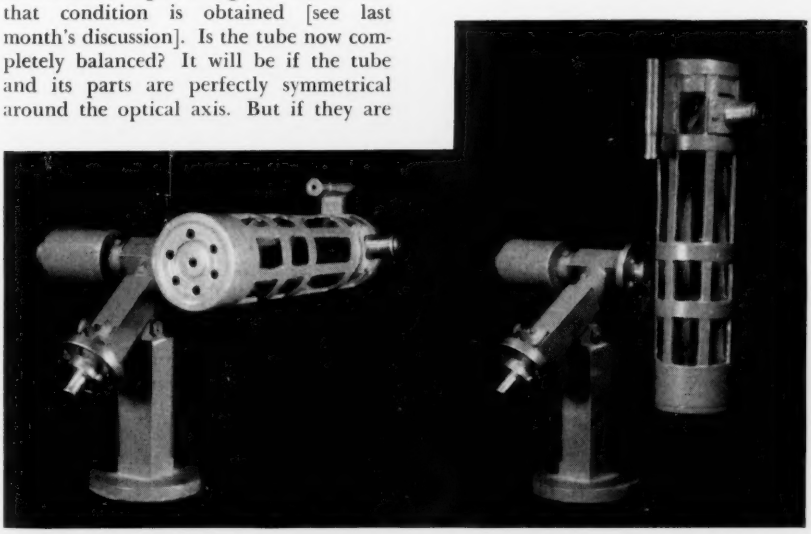
"I have heard many a telescope owner make the statement, 'I cannot get that instrument balanced in all positions.' There should not be any difficulty about this if we keep in mind that a rotating system is only balanced when its center of gravity is on the axis. In the case of a telescope, we have two axes of rotation and we have, therefore, to operate successively in four positions.

"**Position I.** First, we adjust the balance of the tube in declination, pointing the telescope horizontally in the meridian. We check if the tube moves with equal ease up or down and if necessary shift the counterweight along the tube until that condition is obtained [see last month's discussion]. Is the tube now completely balanced? It will be if the tube and its parts are perfectly symmetrical around the optical axis. But if they are not, the center of gravity (G in the diagram) may not be exactly on the axis. All that we have obtained by the counterweight adjustment in this first position is to bring G in the vertical plane of the declination axis at D. We cannot tell if G is not somewhat above or below D. Suppose it is above D; how can we check to find the actual situation?




**In position I the center of gravity G is shown above and to the right of D. In position II, G is to the right and on the near side of the tube, causing its upper end to move southward.**

"**Position II.** By turning the telescope to the zenith. The position of G is now in front of D, as we view them here, with the result that the telescope tube will move more easily to the south than to the north. To correct this we have to move some of the counterweight horizontally (around the tube) until G coincides with D. We can tell this is the case when the telescope moves with equal ease north or south of the zenith. It is important that the counterweight be moved only around the tube, in order not to



**The stability of a German-type mounting around the declination axis should be checked in the positions pictured here, I (left) and II. They are illustrated by a model six inches high made by Cliff Raible, a member of the Amateur Astronomers Association of Pittsburgh.**

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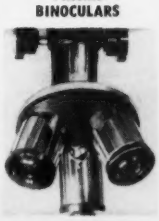

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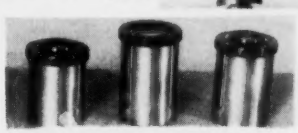

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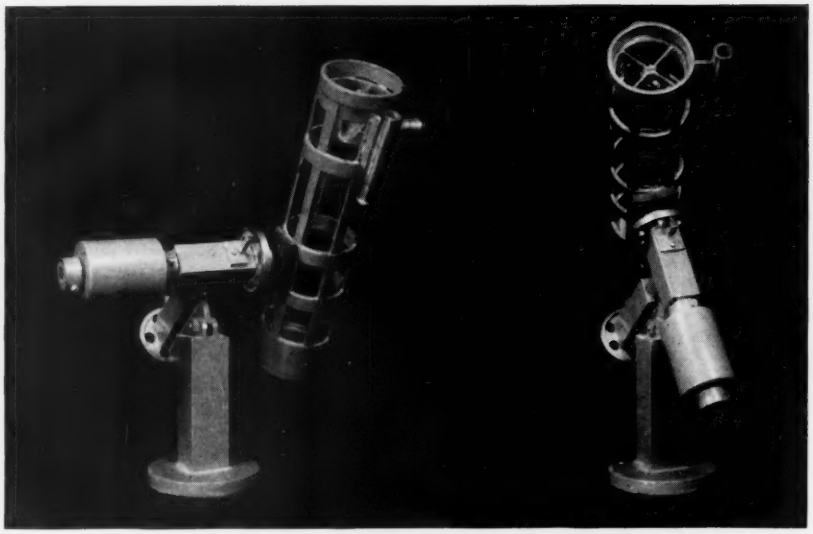


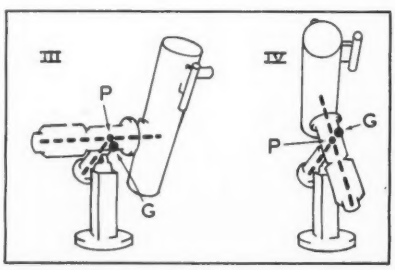
**Balance around the polar axis should be checked in positions III (left) and IV. If in position IV the telescope tends to swing to the right (clockwise as seen from the north), the additional counterweight should be placed on the left (eastern) side of the central block of the declination assembly.**

disturb the balance already achieved in position **I.** Now the instrument will be in balance in declination in all positions.

**"Position III.** The same reasoning applies to the polar axis, and in the diagram P is the point of intersection of the declination and polar axes. Point the tube anywhere along the meridian, so the declination axis is horizontal, the tube being on one side of P and the declination counterweight on the other side. We adjust that counterweight inward or outward on its supporting shaft until the motion around P takes place with equal ease east or west. Again we ask: Is the telescope completely balanced now? No, because we only know that the center of gravity G is in the vertical plane of the polar axis. In this position we cannot tell if it is above or below P, nor how much.

**"Position IV.** To check this we move the instrument around the polar axis east or west six hours from the meridian. The center of gravity, if not originally exactly at P, has now moved east or west of it, a fact that becomes evident when we find that the instrument in this fourth position does not rotate with equal ease in both directions.

"How do we correct this? Not by changing weights on the telescope tube, for this would disturb the balance in declination. Not by changing the position




**Adjusting the counterweight in position III brings the center of gravity into the vertical plane of axis P. If G is below P, then G will be on the west side of the pier in position IV. To compensate for this, a counterweight is to be placed on the east side of the declination housing.**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of the counterweight on the declination axis, for this would have no effect, as in this fourth position it already is in the vertical plane of the polar axis. The remedy is to install a weight at right angles to the plane formed by the declination and polar axes, that is, on the east or west side of the equatorial head as it is set in position **IV**. A convenient position for such a counterweight may be on the equator point of a fixed declination circle, but in that case a slight final adjustment has to be made in position **III**.

"Not until the balance has thus been checked in the four mentioned positions can we be sure that the instrument is in equilibrium in all orientations required during observing. Most telescope makers fail to obtain that condition because they omit checking in positions **II** and **IV**. Many a good-sized instrument built by a reputable manufacturer is not free from defects in balance, owing to the neglect to test in all four positions, especially the last one."

These instructions apply also to the English cross-axis design, which employs a counterbalance on the far end of the declination axis. Fork, yoke, split-ring, and other mountings that do not have such a counterweight, should particularly be checked in positions **II** and **IV**. The last position is especially important where worm gears and their housing may be added to the declination assembly.

Some amateurs have no counterbalance on the declination axle, as the weight of the extended shaft is sufficient to maintain equilibrium. Though this may seem desirable, it does not provide for adjusting the balance when accessories are added to the tube, and the longer shaft required may get in the way of the observer and of persons waiting to observe. I prefer a counterweight of at least several pounds, not too close to the end of the shaft, with provision for clamping the weight in any position. A short shaft reduces any tendency of the counterweight to vibrate.

A practical method of determining how much counterweight is needed on the declination axle is to hang a pail about six inches from the end of it while the telescope is constrained in position **III**. Fill the pail with water or sand until the assembly stays horizontal without any restricting force. Include the mounting collar and setscrew in the pail, and weigh it carefully.

Some mountings have a counterbalance on the lower end of the polar axle, to bring the center of gravity of the entire instrument directly over the supporting pier or tripod. However, it may also be part of a balancing system like that outlined by Joseph C. Boyle in this department for December, 1952. He describes the use of auxiliary counterweights to take care of lack of balance introduced by faulty construction of the parts of the telescope. R. E. C.


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The need for such clamps is avoided by the simplest of expedients: a damp cloth laid out on the table or counter. The board that holds the tool is set upon the cloth, which provides enough friction to keep the board from slipping. The cloth also acts as a simple governor, for any slippage means that the mirror and tool are binding because of too dry an abrasive mixture, or that there is improper contact between the mirror and polishing lap.

By placing the outfit at the corner of the table, the operator can move around it in a semicircle and then back again, turning the tool slightly after each cycle, thus obtaining in the course of time the symmetrical grinding action required to shape a true figure of revolution.

Wet newspapers might be used as a throw-away substitute for the cloth, but the ink might transfer to the furniture. I use a $\frac{1}{4}$"-thick square of rubber carpet padding under the tool to even out any roughness or warping of the board.

I have used this method with fine results to complete a 6-inch pyrex mirror from start to finish, as well as a 10-inch from 600 grit through six hours of polishing. The figure of the large mirror was checked every half hour; throughout the polishing it varied little from an oblate spheroid — the figure never got out of control.

An important part of such control is maintaining good contact between lap and mirror. On page 187 of *Amateur Telescope Making — Book Three,* it is suggested that onion sacking be pressed into the lap to subfacet it, thereby improving contact. This is unsatisfactory because of the knots in the sack, and it can seldom be procured clean enough. A better plan is to use a paper napkin, embossed with a regular pattern. Leave the dry paper napkin between the mirror and lap overnight, and the latter will become nicely indented.

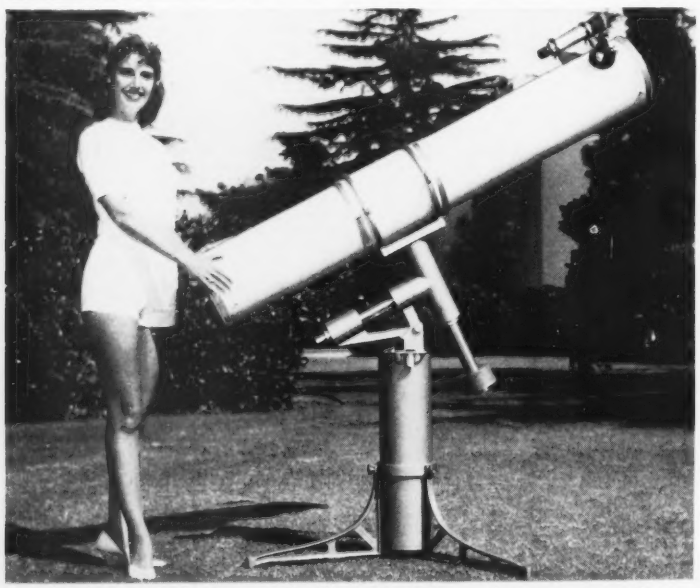
For quicker results, put about 30 to 40 pounds weight on the mirror, and this will give a good pattern in 20 or 30 minutes. For deeper indentations on the lap, industrial napkins should be used; they also are so handy for cleaning up that it is a good idea to have a box of them around while working a mirror. I have heard of plastic screening being used the same way for faceting laps, with excellent results.

To establish good contact between the mirror and the lap, there is advantage in leaving the latter on the mirror. This spreads the lap less than if the heavier mirror were on top. The lap should be thoroughly dry, and its edge should be trimmed to a diameter 1/32" smaller than the mirror, to prevent the sharp mirror edge from indenting the pitch. Prolonged pressing with a napkin lessens further the risk of sticking, although I have left the lap on the 10-inch mirror for a week without a napkin and had no freezing. A precaution before prolonged pressing with a plain pitch lap is to work it until the surface is well charged with polishing compound; if this is not done, binding will occur.

When working with fine grits or rouge, try adding a few drops of a photographic wetting agent, such as Kodak Photo-Flo, to help spread the abrasive around on your tool or lap.

In looking for small pits, scratches, or an under-polished edge on a mirror, a photographer's photoflood lamp helps greatly. Such a 500-watt light shows up mirror defects with almost painful clarity. During this examination, the mirror should have a black background, such as an uncurtained window looking out into the darkness of the night sky.

JOHN COKOR
2635 Delaware St.
Wickliffe, Ohio



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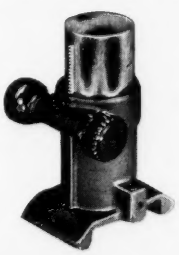

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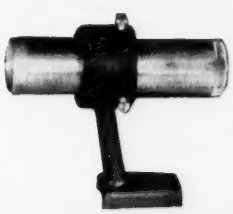

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# CELESTIAL CALENDAR

**Universal time (UT) is used unless otherwise noted.**

## OCCULTATION PREDICTIONS

December 13-14 **Beta Capricorni** 3.2, 20:18.7 −14-54.9, 3. Im: **C** 22:45.4 . . . . . 3. Em: **C** 23:13.3 . . . . . 317.

December 23-24 **64 Tauri** 4.8, 4:21.7 +17-20.9, 13. Im: **A** 21:40.5 +0.3 +2.6 34.

December 26-27 **Lambda Geminorum** 3.6, 7:15.7 +16-37.1, 17. Im: **A** 6:43.1 −1.3 −3.1 147; **B** 6:33.5 −1.4 −2.3 136; **C** 6:55.1 . . . . . 175; **D** 6:30.0 −1.4 −3.1 148; **I** 5:16.9 −0.9 +0.3 123. Em: **A** 7:43.0 −2.2 +0.5 241; **B** 7:41.4 −1.8 −0.1 250; **C** 7:23.1 . . . . . 213; **D** 7:28.4 −2.4 +1.1 237; **I** 6:19.6 −1.1 +2.1 246.

December 28-29 **Alpha Cancri** 4.3, 8:56.2 +12-01.3, 18. Im: **A** 2:26.2 −0.6 +0.1 129; **B** 2:26.6 −0.5 +0.5 118; **C** 2:24.3 −0.6 −0.6 140; **D** 2:23.2 −0.4 +0.4 122. Em: **A** 3:25.6 −0.8 +1.9 256; **B** 3:29.7 −0.8 +1.5 266; **C** 3:14.5 −0.6 +2.4 243; **D** 3:22.6 −0.6 +1.7 261; **E** 3:11.5 −0.2 +1.8 253.

December 29-30 **Pi Leonis** 4.9, 9:58.0 +8-14.8, 20. Em: **F** 7:51.4 −1.4 −2.0 328; **H** 7:17.0 −0.8 −2.2 340.

For stations in the United States and Canada, usually for stars of magnitude 5.0 or brighter, data from the *American Ephemeris* and the *British Nautical Almanac* are given here, as follows: evening-morning date, star name, magnitude, right ascension in hours and minutes, declination in degrees and minutes, moon's age in days, immersion or emersion; standard-station designation, UT, **a** and **b** quantities in minutes, position angle on the moon's limb; the same data for each standard station westward.

The **a** and **b** quantities tabulated in each case are variations of standard-station predicted times per degree of longitude and of latitude, respectively, enabling computation of fairly accurate times for one's local station (long. **Lo,** lat. **L**) within 200 or 300 miles of a standard station (long. **LoS,** lat. **LS**). Multiply **a** by the difference in longitude (**Lo**−**LoS**), and multiply **b** by the difference in latitude (**L**−**LS**), with due regard to arithmetic signs, and add both results to (or subtract from, as the case may be) the standard-station predicted time to obtain time at the local station. Then convert the Universal time to your standard time.

Longitudes and latitudes of standard stations are:

| | | | | | |
|---|---|---|---|---|---|
| **A** | +72°.5, | +42°.5 | **E** | +91°.0, | +40°.0 |
| **B** | +73°.6, | +45°.5 | **F** | +98°.0, | +31°.0 |
| **C** | +77°.1, | +38°.9 | **G** | Discontinued | |
| **D** | +79°.4, | +43°.7 | **H** | +120°.0, | +36°.0 |
| | **I** | +123°.1, +49°.5 | | | |

## MOON PHASES AND DISTANCE

| | | | |
|---|---|---|---|
| Last quarter . . . . . | December 4, | 1:24 | |
| New moon . . . . . | December 10, | 17:23 | |
| First quarter . . . . . | December 17, | 23:52 | |
| Full moon . . . . . | December 26, | 3:54 | |
| Last quarter . . . . . | January 2, | 10:50 | |
| | **December** | **Distance** | **Diameter** |
| Perigee | 9, 0$^h$ | 224,600 mi. | 33′ 04″ |
| Apogee | 20, 21$^h$ | 251,600 mi. | 29′ 30″ |
| | **January** | | |
| Perigee | 5, 20$^h$ | 228,100 mi. | 32′ 31″ |

## MINOR PLANET PREDICTIONS

**Klotho,** 97, 9.0. November 23, 5:47.4 +1-34. December 3, 5:41.1 +0-58; 13, 5:32.9 +0-53; 23, 5:24.5 +1-21. January 2, 5:17.3 +2-20; 12, 5:12.5 +3-41. Opposition on December 15.

**Peitho,** 118, 9.8. November 23, 5:59.6 +30-12. December 3, 5:51.6 +31-15; 13, 5:40.8 +32-08; 23, 5:29.1 +32-44. January 2, 5:18.5 +33-02; 12, 5:10.8 +33-06. Opposition on December 17.

**Egeria,** 13, 9.4. December 3, 6:40.8 +41-40; 13, 6:31.0 +43-20; 23, 6:18.3 +44-35. January 2, 6:04.8 +45-23; 12, 5:52.3 +45-41; 22, 5:41.8 +45-28. Opposition on December 25.

**Winchester,** 747, 9.2. December 3, 6:32.1 −0-03. 13, 6:24.7 +0-54; 23, 6:15.8 +2-22. January 2, 6:06.9 +4-16; 12, 5:59.2 +6-26; 22, 5-54.0 +8-44. Opposition on December 25.

After the asteroid's name are its number and the magnitude expected at opposition. At 10-day intervals are given its right ascension and declination (1950.0) for 0$^h$ Universal time. In each case the motion of the asteroid is retrograde. Data are supplied by the IAU Minor Planet Center at the University of Cincinnati Observatory.

## VARIABLE STAR MAXIMA

December 7, T Centauri, 133633, 6.1; 16, T Herculis, 180531, 8.0; 20, R Ursae Majoris, 103769, 7.6; 27, S Gruis, 221948, 7.8; 30, R Aquilae, 190108, 6.3; 31, S Sculptoris, 001032, 6.8.

January 1, R Andromedae, 001838, 7.0; 4, RT Sagittarii, 201139, 7.9.

These predictions of variable star maxima are by the AAVSO. Only stars are included whose mean maximum magnitudes are brighter than magnitude 8.0. Some, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for maximum. The data given include, in order, the day of the month near which the maximum should occur, the star name, the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern), and the predicted magnitude.

## MINIMA OF ALGOL

December 3, 2:37; 5, 23:26; 8, 20:15; 11, 17:04; 14, 13:53; 17, 10:42; 20, 7:31; 23, 4:20; 26, 1:10; 28, 21:59; 31, 18:48.

January 3, 15:37; 6, 12:26; 9, 9:16.

These minima predictions for Algol are based on the formula in the 1953 *International Supplement* of the Krakow Observatory. The times given are geocentric; they can be compared directly with observed times of least brightness.


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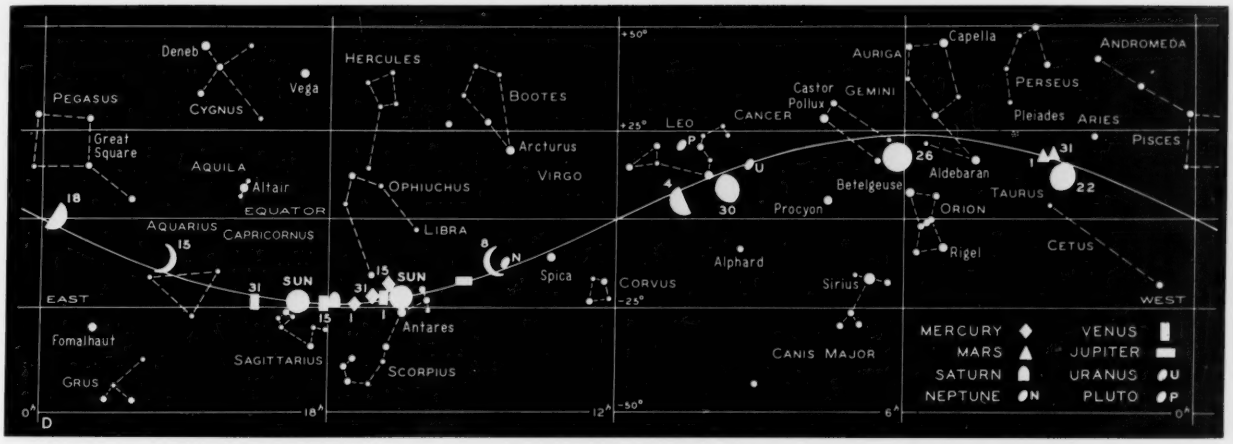


## THE SUN, MOON, AND PLANETS THIS MONTH

**The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month or for other days shown. All positions are for 0h Universal time on the respective dates.**

**Mercury** is too near the sun early in December to be seen, inferior conjunction occurring on the 10th. It then moves rapidly into the morning sky, and by the 29th is at greatest western elongation, 22° 25′ from the sun and rising 1¾ hours ahead of it, before morning twilight begins.

**Venus** at the beginning of the month is in the evening sky very near the sun, but by the 31st it should be visible low in the southwest just after sunset. At this time it is magnitude −3.4 and sets about one hour after the sun.

**Earth** arrives at heliocentric longitude 90° at 8:40 Universal time on December 22nd, the time of the solstice. Winter begins in the Northern Hemisphere, summer in the Southern.

**Mars** is a brilliant object of magnitude −1.1 in Aries on the 15th. It is well up in the east at sunset, visible most of the night. In a telescope the planet presents an almost full disk, 15″.4 in diameter and 96.3-per-cent illuminated. On the 20th Mars is stationary in right ascension, and resumes eastward motion among the stars. On the night of December 21-22 the moon will pass near Mars, being about 4° south at 4:56 UT.

**Jupiter** rises about 2½ hours before the sun in midmonth, and can be seen low in the southeast before dawn as a bright object of magnitude −1.3. Telescopically, Jupiter's disk has an equatorial diameter of 31″.6 and a polar diameter of 29″.5.

**Saturn** is too close to the sun to be seen this month, conjunction occurring on the 20th.

**Uranus** is moving slowly westward in Cancer, being at apparent right ascension 9h 15m.2, declination +16° 40′ on the 15th. The 6th-magnitude object can be seen in the east at midnight, local time.

**Neptune** is on the Virgo-Libra border on the 15th, at apparent right ascension 14h 17m.7, declination −11° 57′. Good binoculars or small telescopes will show this 8th-magnitude planet in the southeast before sunrise.

*Artificial satellite observations* in December may be made with the help of the star chart from an October or November issue for evening twilight, from a May issue for morning.

W. H. G.

## DECEMBER METEORS

As the moon will be near the new phase, conditions for observing the Geminid meteor shower are very favorable this year. These meteors, many of them bright and of long duration, radiate from near the star Castor in Gemini. They will be most numerous on the morning of December 13th, when up to 40 meteors per hour may be seen by one observer. The duration of the shower is given as December 9-14 in the 1958 *Handbook* of the British Astronomical Association.

On the night of December 22-23, the Ursids will appear, with a predicted peak rate of 15 per hour, but the waxing gibbous moon will handicap observers. This is unfortunate, as there is some possibility of a strong shower like that of 1945, when a four-hour display was seen at the Skalnate Pleso Observatory in Czechoslovakia; for 10 minutes a peak rate of 169 meteors per hour was reached (*Sky and Telescope*, July, 1946, page 6). The radiant is not far from the bowl of the Little Dipper.

W. H. G.

## UNIVERSAL TIME (UT)

TIMES used in Celestial Calendar are Greenwich civil or Universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the UT before subtracting, in which case the result is your standard time on the day preceding the Greenwich date shown.


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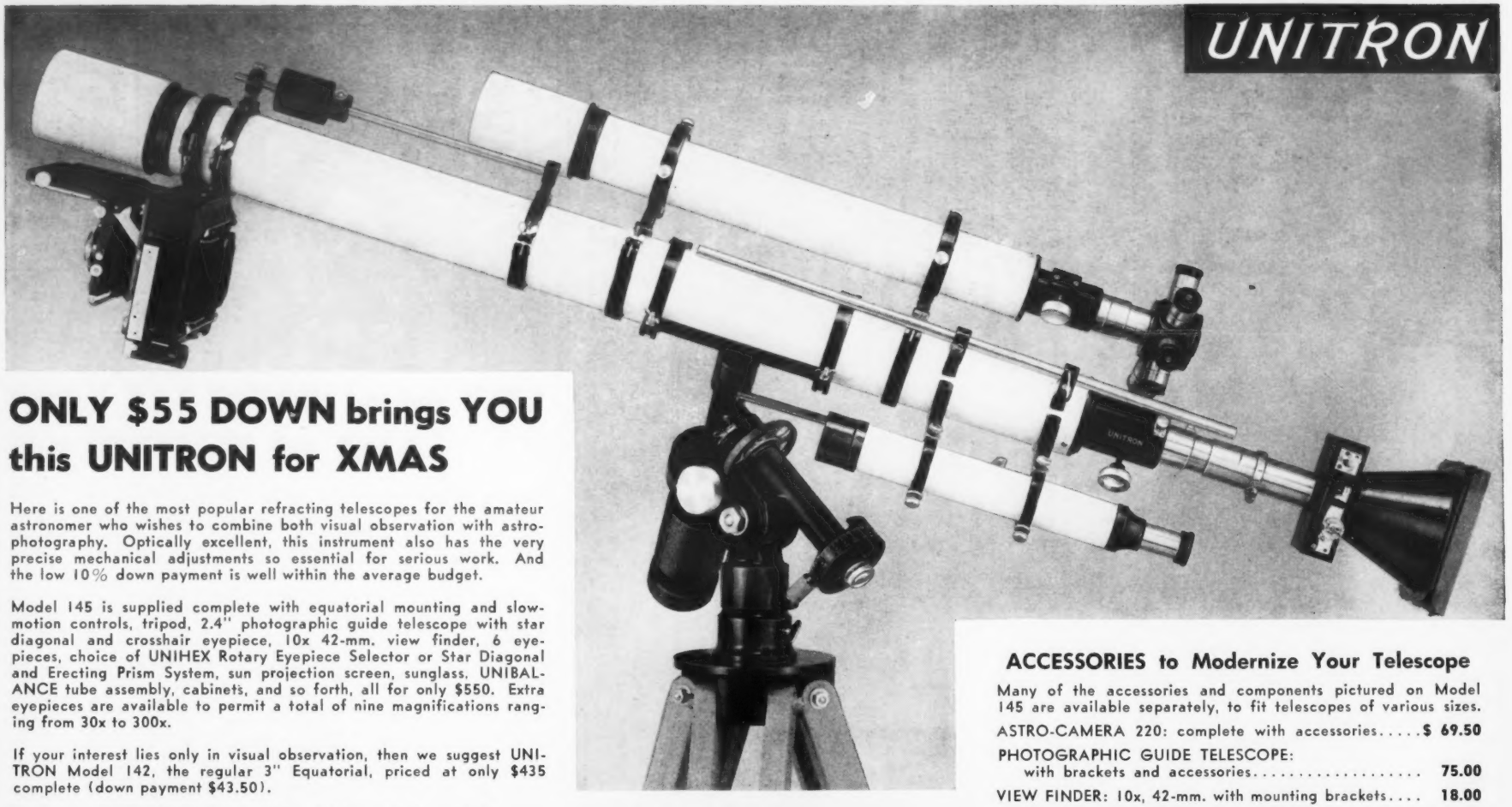


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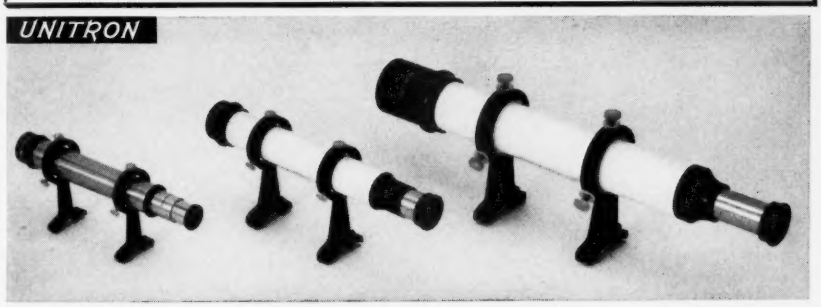


**UNITRON's popular view finders with newly designed optics and mechanical features are better than ever; from left to right: 23.5 mm., 30 mm., 42 mm.**

1. **VIEW FINDER** (Used on UNITRON 2.4" Equatorials): 23.5-mm. (.93") achromatic objective, 6x eyepiece with crosshairs. Chromed brass tube. Mounting brackets with centering screws. **Only $8.50 postpaid**

2. **VIEW FINDER** (As used on UNITRON 3" Refractors): 30-mm. (1.2") coated achromatic objective and 8x eyepiece with crosshairs. Other details as in View Finder 3. **Only $10.75 postpaid**

3. **VIEW FINDER** (As used on UNITRON 4" Refractors): 42-mm. (1.6") coated achromatic air-spaced objective. 10x eyepiece with crosshairs. Duralumin tube finished in white enamel. Dewcap. Furnished with mounting brackets, centering screws for collimation, and mounting screws. This finder measures approximately 16" overall. It is light in weight, compact and small enough for use as a hand telescope furnishing spectacular wide-field views of the sky. **Only $18.00 postpaid**

### UNITRON ASTRO-CAMERA 220 for Refractors and Reflectors

**(Illustrated on facing page):** A lightweight camera designed especially for photography using the objective lens or mirror of the telescope as the principal optical element. It may be positioned to take the image at the primary focus or an eyepiece may be inserted in the camera tube to project a magnified image on the plane of the film. Supplied complete with Thornton-Pickard type air-operated shutter (speeds 1/10 to 1/90 sec., bulb and time), 3 double filmholders 3¼" x 4¼", ground-glass focusing back, extension tubes, 30-mm. f.l. photo ocular, eyepiece holder, filter, clamps, cabinet and instructions. Model A fits the UNITRON rack and pinion. Model B fits 1¼" O.D. eyepiece holders.

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**Send check or money order in full or use our Easy Payment Plan, as described below. Shipments made express collect. Send 20% deposit for C.O.D. shipment. All instruments are stock items and Christmas orders will be shipped the same day as received. For special rush orders and information, telephone HAncock 6-9878 (Boston exchange) and ask for "Christmas Order Department." UNITRON instruments are fully guaranteed for quality, workmanship, and performance, and must meet with your approval or your money back.**

### Use Our EASY PAYMENT PLAN

**UNITRON's popular Easy Payment Plan is a convenient and economical way to buy your UNITRON Refractor when you do not want to disturb your savings or when you haven't the total cost of the telescope immediately available. The down payment required is 10%. The balance due is payable over a 12-month period, and there is a 6% carrying charge on the unpaid balance. Your first payment is not due until 30 days after you receive the instrument, and if you should want to pay the entire balance due at that time, the carrying charge is canceled. (6" models available on special plan.)**

**There is no "red tape" when you order — you merely fill in the UNITRON Easy Payment Order Form, return it together with the required down payment, and the model of your choice is shipped to you at once.**

**Do not hesitate to use this plan merely because you have never before purchased anything on time payments. The procedure is practically painless and is an ideal means of enjoying the use of your UNITRON while paying for it.**

**See the back cover.**

**UNITRON** INSTRUMENT DIVISION OF UNITED SCIENTIFIC COMPANY
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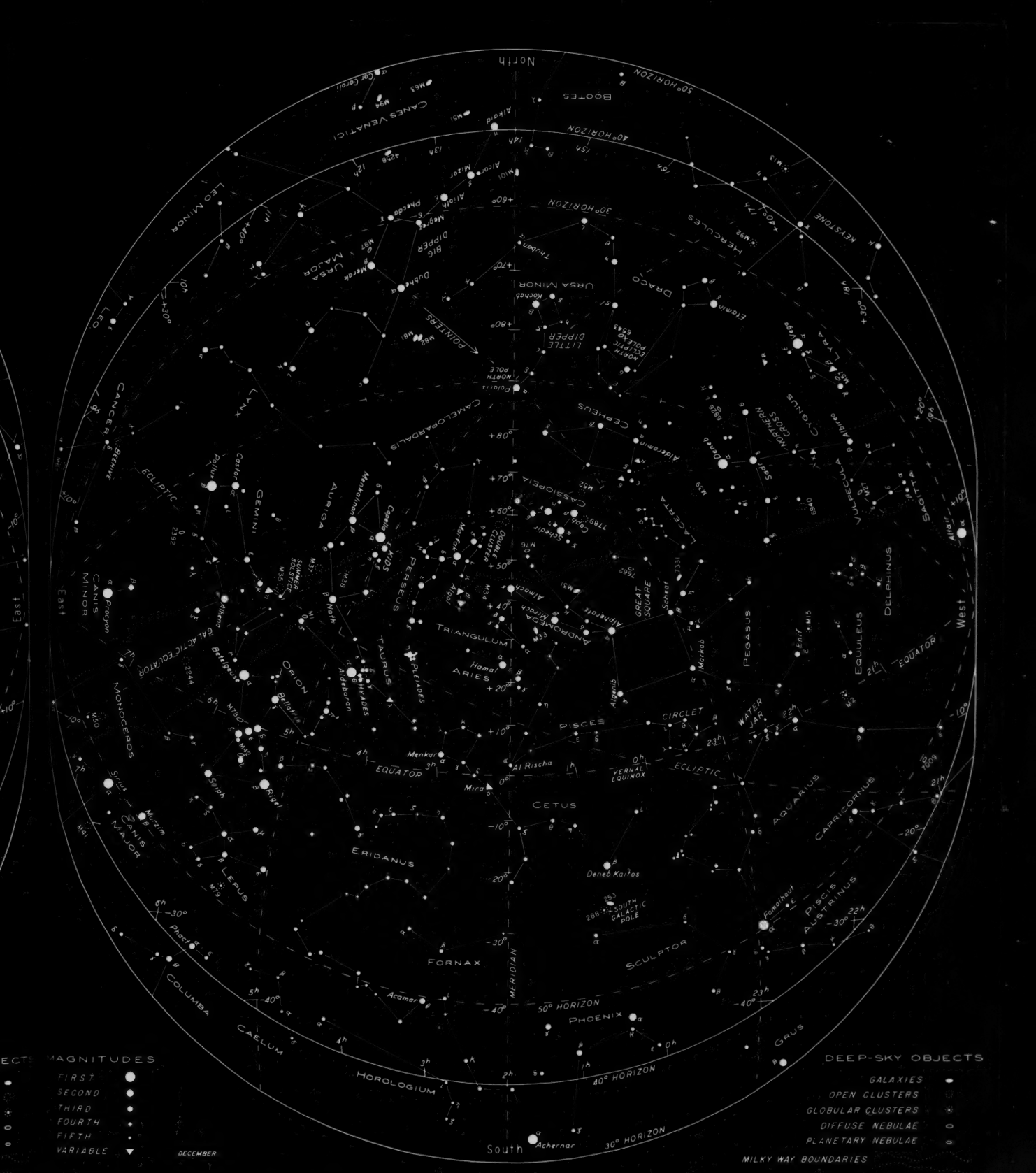
## SOUTHERN STARS

The sky as seen from latitudes 20° to 40° south, at 11 p.m. and 10 p.m., local time, on the 5th and 21st of February; also, at 9 p.m. and 8 p.m. on March 7th and 23rd. For other dates, add or subtract ½ hour per week.

High above the south pole of the sky at chart time are four star groups that once made up the single ancient constellation of Argo, the Ship. They are Carina, the Keel, which contains bright Canopus; Puppis, the Stern; Vela, the Sails; and Pyxis, the Mariner's Compass.




## STARS FOR DECEMBER

The sky as seen from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., local time, on the 7th and 23rd of December, respectively; also, at 7 p.m. and 6 p.m. on January 7th and 23rd. For other dates, add or subtract ½ hour per week.

With Cassiopeia and Perseus close to the meridian, the northernmost stretches of the Milky Way are well placed for observing. Lying midway between these two constellations and close to the galactic equator is one of the finest showpieces in the sky, the Double Cluster in Perseus.

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(4) THREE EYEPIECES — 18-mm. Huygens, 9-mm. achromatic Ramsden, 6-mm. Orthoscopic, giving powers of 65x, 130x, and 195x.

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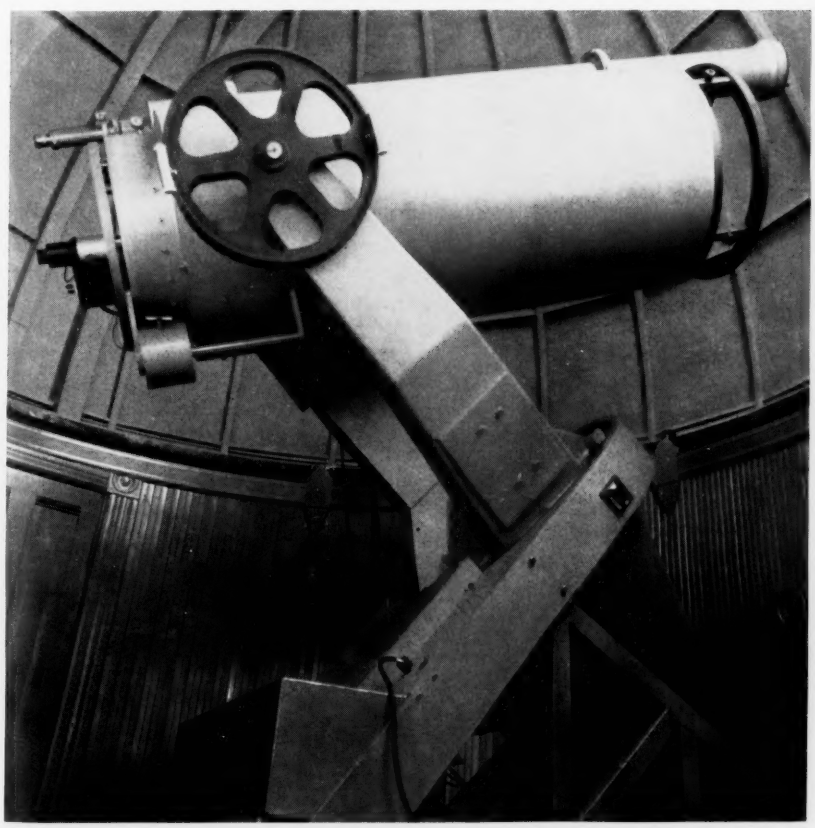
*Above: A standard, motor-driven Astro-Dome constructed of structural steel.*

*Below: A typical Tinsley telescope built to meet professional observing requirements.*



The technical skill of Astro-Dome, Inc., and Tinsley Laboratories guarantees the highest standards of precision in observatory domes and telescopes.

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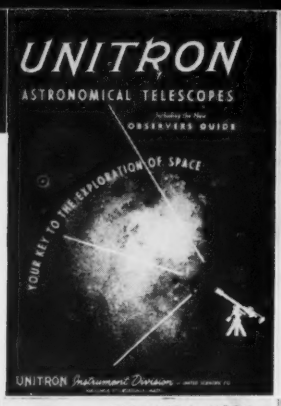
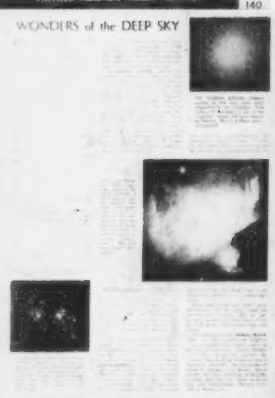


**The sample pages shown here in miniature only begin to hint at the wealth of facts and figures included in UNITRON's colorful, 38-page Catalog and Observer's Guide. The full-page illustrated articles on astronomy are crammed with helpful information — not readily available elsewhere — on observing the heavens, telescopes and their mountings, accessories, amateur clubs, astrophotography, and the like. There is even a glossary of telescope and observing terms. Whether you are a beginner or an advanced amateur you will certainly want a copy of this remarkable publication for your bookshelf. Use the handy coupon, a postcard, or letter to request your free copy of this valuable guide.**

**Those who are considering the purchase of a telescope will find it especially worth while to learn more about the distinguished line of UNITRON Refractors and Accessories which play so important a role in astronomy today. For only by a careful comparison of the features, quality, and performance of different instruments can the prospective buyer insure that his telescope will be worthy of his investment and of the time he will devote to observing. It's truly easy to own a UNITRON. A down payment of only 10% puts you at the controls and you have 12 months to pay the balance. Full information is included in the UNITRON Catalog. Send today for your free copy.**



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